THE EFFECTS OF COGNITIVE ABILITY AND DECISION SUPPORT ON HIGH-SPEED DECISION-MAKING BY NOVICE SHARE TRADERS: EMPIRICAL STUDIES IN FINANCIAL TRADING

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STATEMENT OF ORIGINALITY

The work presented in this thesis is, to the best of my knowledge and belief, original and my own work except as acknowledged in the text. The material has not been submitted, either in whole or in part, for a degree at this or any other university.

This thesis is an outcome of my participation in an Australian Research Council funded research project "Floor Trading versus Computer trading – Does it Matter?" (DP0343994). The experiments were conducted jointly to serve the different research aims. The cognitive abilities, rapid decision making and decision support components that form the basis for this thesis lie outside the scope and involvement of the ARC project focus.

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(ALEXANDER PHILLIP RICHARDSON)

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treat education seriously before you get to university.

Abstract

The nature of investing in share markets is undergoing significant changes due to the growth in electronic or online trading. Online trading has meant increased trading by new types of traders, who are often relatively inexpert. It is a risky undertaking for novice share traders to trade in a real-world market. Their lack of experience means they can struggle to adequately form correct pricing decisions for securities. Decision support systems can be designed to reduce the cognitive burden of traders, though within the academic finance literature their usefulness is little studied. The lack of published studies may be attributed to the requirement of confidentiality when decision aids provide a monetary advantage over others in the market. This paucity of research motivated the current research. The study's primary research questions are (i) to what degree do the cognitive abilities of novice traders influence financial performance; and (ii) how beneficial in a time constrained environment is decision support for differing levels of cognitive ability?

This study used two experiments to examine the influence of decision support for novice traders as well as the effect of cognitive abilities and decision-making speed on financial performance. The results of the first experiment confirmed the hypothesis that higher crystallised ability (general knowledge) was related to higher performance, though fluid ability (innate ability) and quantitative knowledge (mental mathematics) were not. The results suggest that relatively inexpert traders with less well-developed cognitive abilities related to long-term memory and general knowledge (i.e. crystallised ability) may be at a disadvantage. A second experiment investigated these findings in further detail when a decision aid was provided to one group of novice traders. It was found that novice traders who had decision support consistently outperformed those who did not. The decision aid also mitigated the negative effect of

higher decision-making speeds and lower cognitive ability. Both experiments used a controlled computer-based continuous double auction share market to examine these effects.

This research significantly enriches the body of behavioural finance studies by addressing the effects of cognitive ability and decision support on financial trading when decision-making speed varies. It has been shown that financial trading performance also relies upon cognitive abilities. This research also adds to the literature on rapid decision-making under time pressure. Little is known about the effects of varying time constraints because historically research has used fixed arbitrary time limits.

To focus upon the cognitive characteristics of the participants when manipulating the presence of a decision aid, it was necessary to use a controlled experimental environment to limit the influence of outside influences. The ability to generalise these findings to naïve traders in a real share market (for example, ASX, NYSE and Hang Seng) is somewhat minimised because of this. Nonetheless, the strength of this thesis lies in demonstrating that there is some relationship between cognitive abilities and share trading performance for naïve traders and that a decision support tool (aid) can mitigate the effects of lower cognitive ability on performance in a time constrained environment.

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Abbreviations

ASX	Australian Stock Exchange
CDA	Continuous Double Auction
DA	Double Auction
DSS	Decision Support System
EDP	Electronic Data Processing
EMH	Efficient Market Hypothesis
FTS	Financial Trading System
IELTS	International English Language Testing System
IQ	Intelligence Quotient
NYSE	New York Stock Exchange
RE	Rational Expectations
SEATS	Stock Exchange Automated Trading System
SD	Standard Deviation
SEC	Security Exchange Commission
TOEFL	Test of English as a Foreign Language

Chapter One
Introduction

'A fool and their money are soon parted.'
– Anonymous

1.1. Background

Online share trading has become popular across a diverse population of traders due to an increase in public awareness of online services and the relative ease of gaining access to the share market. Share trading is no longer restricted to expert brokers on trading floors. Instead, online trading systems allow a wide range of traders with varying abilities and experience to participate in buying and selling shares. A number of these traders, apart from having relatively limited exposure to finance and the principles of financial markets, may also be lacking in high-level quantitative skills. Online financial markets allow trading to occur rapidly, with the traders making decisions at high speed (Odean, 1999; Barber and Odean, 2002).

1.2. The Specific Problem

Novice traders with limited knowledge of finance and possibly limited cognitive processing ability engaging in rapid decision-making, where the stakes can be high, would appear to be a recipe for disaster. The beneficial second opinion provided by a share portfolio financial advisor is often no longer present with online trading. Without a level of expertise to constrain aberrant decision-making behaviour, novice traders can be cognitively overloaded and compensate by choosing a decision model that may be overly simplified or simply wrong.

1.3. A Decision Support System Solution

One of the many benefits of a properly designed decision support system (DSS) is that it enables users to extend their decision-making ability in processing cognitively complex problems that would otherwise be beyond their ability or take significantly longer (Marakas, 1998). When modelling the share market in information systems terms, the value traders place on shares reflects their private information and the combined knowledge of all the traders within the market. The resulting price output reflects the aggregate information for that share (Fama, 1970). With hundreds of stocks to trade and thousands of transactions per day, the amount of data to be collected and analysed is beyond the cognitive abilities of a single individual. In these circumstances, there appears to be the potential for a DSS to assist individual traders.

1.4. Objectives of the Research

For many years, researchers using the efficient market hypothesis (EMH) have taken the view that any advantages provided by decision support systems are soon negated by the dispersal of information throughout the market. To date, this view is still accepted, although interest in behavioural finance and agent-based models of markets is growing. By studying agents within a market as individuals, further insight into market mechanics can be gained and the factors that affect the relative performance of individuals rather than the behaviour of the market as a whole can be understood.

This thesis study focuses on novices and the influence of three factors on individual performance in share trading: cognitive ability, time constraint and decision support. The influence of cognitive abilities on financial trading performance, regardless of experience classification, has not been investigated previously. Existing research has

shown, in general, that as decision-makers become more experienced, their decision process matures and decision aid requirements change (Payne et al., 1993).

Professional traders have the benefit of experience and policies for conducting trades and, therefore, devise strategies to make profits. Novice traders, however, may lack the maturity of knowledge gained over time and rely upon a smaller subset of skills and behavioural characteristics. This immaturity in trading is further hampered by a need to cope with significant levels of cognitive load when making basic mental calculations. The limited cognitive capacity of novice traders necessitates their using compensatory decision-making processes when making trading decisions.

It is postulated that novice traders will find a decision aid beneficial as they have yet to optimise the decision-making process to maximise performance from their limited cognitive abilities. There has been very little research into the application of decision aids in financial trading, and no studies have focused on cognitive abilities in a trading environment (with or without any decision aid).

Studies of the effects of time constraints on decision aid effectiveness have been limited to those using arbitrary fixed time values. Share markets typically require rapid and quality decision-making. Their competitive nature makes minimising the time between an opportunity arising and taking action advantageous. Other traders will not (normally) purposely delay a decision to provide a fair playing field. Instead, the time constraints placed upon individuals vary according to the decision-making capabilities of other agents.

This current state of understanding by researchers and the gaps in existing theory lead to the main research question for this study:

> *What is the relationship between decision support, cognitive abilities and time constraints and how do these factors affect financial performance in share trading by novice traders?*

By addressing this question, the study makes the following theoretical and practical contributions regarding novice traders:

- It is one of the first behavioural studies in finance to examine the influence of multiple cognitive abilities on financial performance.
- It provides a richer understanding of how variable time constraints within a competitive trading environment affect financial performance.
- It increases our understanding of the effects of a decision aid on financial trading performance within an experimental double auction market.
- It assesses the significance of different cognitive abilities on the effectiveness of a decision aid.
- It extends the decision support literature by investigating variable, not fixed, time constraints on decision-making.

The decision aid used in this study aims to guide a novice trader towards a more accurate decision encompassing as much available information as possible rather than one based on individually chosen compensatory methods that discard potentially useful information. By supporting the fundamentals of pricing a share, it is proposed that a cognitive support tool (aid) can provide a positive financial performance benefit

to novice traders over those without similar cognitive support. Their enhanced decision-making ability will allow greater levels of multitasking due to more memory intensive calculations being simplified. This will allow the decision-maker to allocate cognitive resources to other necessary tasks. Alternatively, those cognitive resources may be used to increase decision-making speed and relieve pressure felt as a result of the time constrained environment. Faster decision-making provides a competitive edge due to the time critical windows of opportunity created in real-time share trading environments.

1.5. Scope of the Research

For the purposes of this study, the type of financial trading environment examined is the continuous double auction (CDA). The double auction (DA) has been demonstrated in experiments conducted since the early 1960s (Smith, 1962) to be the most efficient and competitive trading environment and the one that most closely resembles the modern stock market. Given that it is impractical to attempt to model a real stock market, the choice of a CDA market means that the results of this study may be generalised to an environment with similar interfaces and mechanisms. The CDA market allows for a large number of influential factors (eg. global economic effects and intangible information sources) acting upon real stock markets, such as the ASX, NYSE or Hang Seng, to be controlled for. An increased understanding of human decision-making in an experimental market will greatly complement current research into the use of artificial agents designed to interact with the market that are based on a set of mathematical rules.

In a competitive environment, any tool which provides a monetary advantage over a competitor has inherent value to the user. As a result of this value, the design of such tools tends to be kept confidential; disclosure of how the tool provides an advantage would mitigate its effectiveness due to other users now being aware of the method, essentially levelling the playing field among professionals. Adding to the limited body of published DSS knowledge for financial share trading support systems will help to fill this gap.

Another potential result of expanding DSS knowledge is to level the playing field between professionals and novices. Learning to trade shares is often fraught with the danger of monetary loss, and this loss negatively influences future behaviour and confidence. With its focus on naïve (i.e. novice) traders, it is expected that traders in this study will be able to devote more time to learning trading fundamentals without being bogged down in cognitively expensive calculations. This means that as their experience progresses, those cognitive resources can be utilised more efficiently. This enhanced decision process is expected to lead to high trading profit performance.

Put succinctly, this study investigates the performance of novice traders in an online share trading environment. One of its premises is that the increased cognitive load that comes with rapid decision-making is likely to lead to reduced performance (Payne et al., 1993). The study also investigates whether trading performance varies with cognitive skill and whether the provision of decision support in this environment will help to overcome problems with high-speed decision-making and limited cognitive ability.

1.6. Methodology

The study used an experimental design. Questionnaires were employed to elicit the participants' self-rated level of confidence regarding the task they were to undertake and to measure their understanding of the trading process. The first experiment served as a baseline study of how well novice traders, with little to no prior trading experience, behave in an experimental market having regard to the effects of their cognitive ability. In the second experiment, a decision aid was introduced to measure its effect upon the novice traders' financial performance.

Several published studies (Williams, 1980; O'Brien and Srivastava, 1991; Gode and Sunder, 1993; Brandouy et al., 2001; Poggio et al., 2001) show that experimental designs are suitable for this type of research. Computer-based electronic financial markets are an accepted controlled environment for studying the influence of cognitive factors upon traders. Experimental share market software allows action-by-action interactions between traders to be recorded. Finally, experimental market theory is sufficiently mature to allow hypotheses to be developed and tested experimentally.

1.7. Outline of the Thesis

Chapter 1 outlines the current state of research on cognitive ability and decision-making and how this study aims to address its gaps and shortcomings. Chapter 2 takes the key concepts from the literature review in Chapter 1 and presents the research problem in more detail, from which several hypotheses are developed. Chapter 3 explains the choice of methodology used in the study. Chapter 4 presents the details of a computer-based experiment undertaken to capture quantitative share trading data

from the experimental financial market. This experiment served as a foundation for understanding the expected behaviour of novice traders operating without decision support. It also explains the application of the research methods to the data collected and presents an analysis of the results. A regression analysis was used to determine the effects of decision-making speed and cognitive abilities on the participants' financial trading performance.

Chapter 5 reports the results of the main study, which builds on the baseline research presented in Chapter 4. It describes a computer-based experiment examining the differences in trading performance of novice traders using a decision support aid and those not. The chapter explains the application of the research methods to the data collected and presents an analysis of the results. A regression analysis was used to determine the impact of the decision aid, decision-making speed and cognitive abilities on financial trading performance. Chapter 6 draws conclusions from the hypotheses and research problems defined in Chapter 2 based on the findings from the empirical tests reported in Chapters 4 and 5.

1.8. Definitions

Continuous double auction (CDA) – a type of market where participants enter 'bid' and 'ask' and 'buy' and 'sell' transactions on a continuous basis.

Crystallised ability – 'includes what we learn in our time at school, as well as the skills, experience and knowledge we acquire later in life. It increases through to adulthood and then tends to remain constant. It depends on long-term

memory, which is less prone to the ageing process.' – e-bilities - Theoretical background (2007)

Efficient market hypothesis (EMH) – asserts that the price of a share on average reflects all known information and knowledge available to the market and that the market cannot be consistently outperformed by using information already known to the market.

Fluid ability – 'refers to 'pure' or untutored thinking that depends largely on working or short-term memory. There is a genetic, neurological basis to our fluid ability, and it tends to decline in later life. This is because our working memory deteriorates as we grow old.' - e-bilities - Theoretical background (2007)

Rational expectations (RE) – a market where expectations are realised on average and where the predictions made by decision-makers contain no systematic errors.

Time constraint – A deadline or restriction imposed upon a task when the decision-maker has a limited amount of time in which to make the decision. This constraint is often fixed to a particular value for experimental purposes either arbitrarily or based on previous findings.

Time pressure – The stress induced as a result of time constraint on a human decision-maker. It is possible to have a time constraint but not time pressure if the decision-maker can arrive at a decision within the time constraint period.

Quantitative knowledge – 'the ability to solve numerical problems.' – e-bilities - Theoretical background (2007)

1.9. Delimitation of Scope

This study should not be interpreted as portraying that a DSS can provide a financial advantage in all circumstances. It argues that the use of a DSS can provide much-needed cognitive support for novice traders to increase their ability to make a financial gain relative to trading peers who operate without such support.

The decision aid was custom designed and may not be representative of other decision aids. The information it presents was derived from observation and participant insight obtained during earlier experiments. The presentation style was developed from accepted design guidelines for tabular data.

1.10. Conclusion

This chapter has provided the foundation for the development of the thesis in the following chapters. It has presented the background to the research, the research problem and accompanying hypotheses, the reasons for the research, the choice of methodology, the thesis structure, definitions of key concepts and the scope of the research.

Chapter Two
Research issues

'Sometimes your best investments are the ones you don't make.'
– Donald Trump

2.1. Introduction

The motivation for this research came from an interest in the performance of non-specialist share traders in online trading, a situation characterised by high-speed decision-making and non-expert decision-makers. A further interest concerned whether a decision support system could assist decision-makers in this environment and, if so, how. The topic is significant because this combination of circumstances has been little studied and has both theoretical and practical significance.

The value of, and motivation for, this thesis can be explained by three statements:

1. The research literature on DSS and share markets is well-established. Each discipline has its own premises and the disciplines rarely overlap.
2. The understanding of time constraints on decision-making within each discipline is incomplete and needs clarification.
3. The relationships among cognitive ability and decision support and time constraints has received little attention.

As stated in Chapter 1, this study examines the following research question:

> *What is the relationship between decision support, cognitive abilities and time constraints and how do these factors affect financial performance in share trading by novice traders?*

The chapter proceeds as follows. First, the literature on financial trading is described to set the context for the study. The literature on decision-making, particularly by non-experts, is then reviewed. The role of their cognitive abilities is considered in particular. It is concluded that the cognitive ability of non-expert decision-makers is likely to affect their decision-making performance. The topic of decision-making under time pressure is then explored. Research in this area indicates that reduced decision-making time has detrimental effects on decision-making performance. A subsequent examination of the literature suggests that a decision support system can assist naïve decision-makers in a time constrained environment if it relieves them of some of the cognitive burden associated with the decision-making.

The penultimate section of the chapter presents a research model that draws together the preceding argument and summarises the propositions advanced in the body of the chapter. The concluding section summarises the chapter and revisits the significance of the research.

Throughout the chapter, the discussion relates to a share trading context. Three factors used to explain trading performance are cognitive abilities, decision support and time constraints. The overlap of these factors is expected to influence financial performance. The circular nature of this influence is depicted in Figure 2-1.

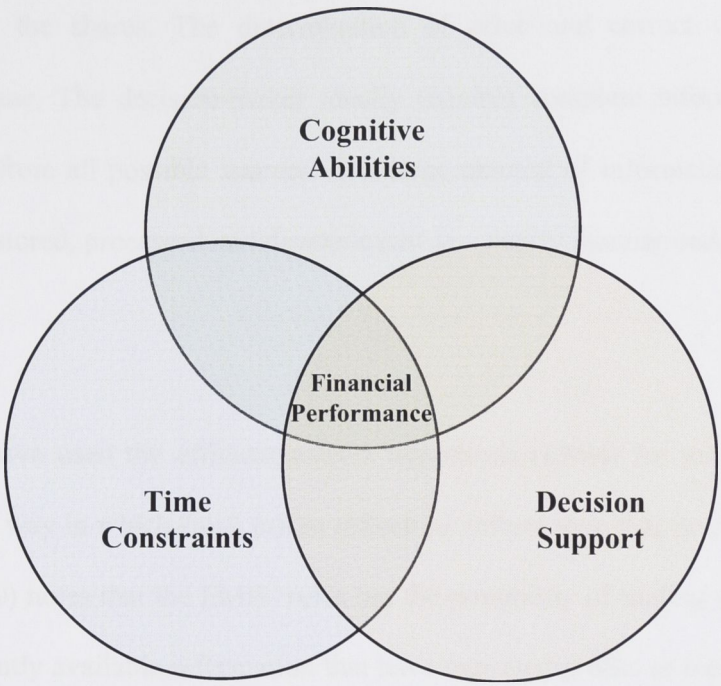

Figure 2-1- The 'Circles of Influence' Research Model

The influence of each variable creates certain questions of interest:

- Do the cognitive abilities of novice traders influence their performance in a share market trading context where high-speed decision-making is required?
- Do time constraints influence performance in a decision-making environment?
- Can a decision support tool (aid) improve the performance of novice traders in a share market environment, a situation where decision-making is constrained by time and traders have varying cognitive abilities?

2.2. Financial Trading Context

2.2.1. Efficient Market Hypothesis and Rational Expectations

For more than 400 years, share markets have allowed shareholders in a company to buy and sell their shares in the company. The market price of each share reflects its perceived market value and fluctuates as traders continuously agree upon prices to

buy and sell the shares. The determination of price and correct valuation is a significant issue. The decision-maker ideally requires complete information that is accumulated from all possible sources. The large amount of information required to be collected, stored, processed and disseminated in a timely manner makes such a task unfeasible.

Economists have used the efficient market hypothesis (EMH) for many years as a model for the way in which stock prices reflect the information that investors possess. Shliefer (2000) notes that the EMH 'rules out the possibility of trading systems based only on currently available information that have expected profits or returns in excess of equilibrium expected profit or return (Fama, 1970)'. Simply put, an average investor cannot consistently beat the market and any resources expended to an attempt to do so are therefore wasted. Jensen (1978, p. 95), one of the creators of the EMH, declared that 'there is no other proposition in economics which has more solid empirical evidence supporting it than the Efficient Market Hypothesis'.

The rational expectation (RE) model holds that a market consisting of rational players will eventually converge to trading steadily at an equilibrium price p*. This is also known as rational expectation equilibrium (REE). There are two basic forms to the RE model: the weak and the strong. The weak form states that traders make optimal use of whatever information they have when forming their expectations and that there is no restriction placed upon the information. The strong form, however, states that traders have access to all information available to them about the structure of the world containing the market and that they make optimal use of this information when forming their expectations.

The concept of market efficiency is similar, though it is based more on the ability of prices to reflect information. There has been considerable controversy over the years concerning market efficiency. Recent thought on this concept suggests that the market is efficient with respect to publicly available information only. There are a number of questions concerning private information and asset pricing models that suggests the need for care (Fama, 1970, 1991). It is argued that information, once public, is rapidly reflected in prices as traders and investors buy or sell assets until there is no further benefit to be gained from the information. Thus, through a process of trading, information is eventually reflected in price as the price converges to the some fundamental equilibrium value. This can occur very rapidly, as is the case of profit releases for large corporations.

As with many strong statements, challenges soon arise. The strength of the components that form a key part of the EMH, that are meant to obtain efficiency, have been questioned. Newer studies investigating security prices no longer favour EMH as they once did. Behavioural finance has started to emerge as an alternative view of financial markets (Shleifer, 2000).

2.2.2. Behavioural vs Traditional Finance

Behavioural finance is the application of psychology to the financial behaviour of practitioners (Shefrin, 2000). Shefrin identifies three themes of behavioural finance:

1. Do financial practitioners commit errors because they rely on rules of thumb?

Advocates of behavioural finance would agree. Investors use the rules of thumb (also known as heuristics) to help them process data. The rules of thumb can be based on previous experience (eg. 'Past performance is the best predictor of future performance') as well as established trading strategies (eg. 'Buy low, sell high'). Shefrin (2000) assigns this investment behaviour the label 'heuristic-driven bias'.

Those with a traditional view of finance would disagree that practitioners rely on rules of thumb. Traditional finance assumes that practitioners process data completely by using statistical tools (e.g., reasoning, calculations, trend analysis) appropriately and correctly.

2. Does form (the description or frame of a decision problem) as well as substance influence practitioners?

Those with a behavioural finance perspective would agree. It is postulated that the practitioner's perceptions of risk and return are highly influenced by how the problem is framed (subjective). For example, traders are more accepting of negative information and question positive information. (This is why the share trading system discussed later in this thesis emphasises what cannot occur in the market.) Shefrin (2000) labelled this link to context 'frame dependence'.

Supporters of traditional finance would disagree. This approach assumes frame independence, where all decisions are viewed through the objective lens of risk and return.

3. Do errors and decision frames affect the prices established in the market?

Researchers using a behavioural finance framework would agree. If practitioners use heuristics and are subject to framing effects, it is assumed that this will cause market prices to deviate from fundamental (true) values. Shefrin (2000) refers to this third theme as inefficient markets.

This contrasts with the traditional finance viewpoint. Traditional finance follows the EMH, where price coincides with fundamental value, even if some practitioners have a heuristic bias or frame dependence.

Simply put, behavioural finance highlights the human aspect of a real world market. Traditional finance tenets may still be strongly held in many quarters, but they are not an all-encompassing view of a share market, where in fact human decision-makers suffer from human fallibility.

2.2.3. Electronic Trading Systems

The use of electronic trading systems in stock exchanges is comparatively new. Since the 1960s, experiments have been conducted to identify the implications of economic theories of price formation on financial markets (eg. Smith, 1962). As a consequence of this work, the benefits of increased efficiency through electronic auction

mechanisms were realised (Cassidy, 1967). It was not until the late 1970s, however, that automated computerised electronic markets started to become a reality due to the need for a Securities and Exchange Commission (SEC) mandated national security market in the USA. Though they are quite rare in modern financial markets today, open outcry markets had historically provided the means for transactions between traders on the trading floor.

As both the number of companies listed on the exchange and the quantity of trades increased, the shout and chalkboard method became more contentious because of information and order delays. To address these inefficiencies, stock exchanges gradually implemented hybrid floor based and computer based order systems. Computer based trading systems became their eventual successor. The data processing capabilities brought vastly increased efficiency, the better dissemination of price information and an opportunity for brokers to interact with the market via screen-based trading clients at multiple locations.

2.2.4. Experimental Markets

Market microstructures have been studied in experimental markets with human traders, where controlled conditions allow insights into market behaviour (Davis and Holt, 1993; Kagel and Roth, 1995). A focus in much of this work is information dissemination and aggregation and tests of the RE model. There is still room for further work in this field. Some studies show that information is disseminated efficiently (Plott and Sunder, 1982, 1988, Forsythe et al., 1982) but may become less efficient when trader behaviour changes (Gode and Sunder, 1993).

Modelling a large share market such as the NYSE or the ASX is not feasible with current technological capabilities; there are simply too many factors to consider when creating an accurate model. Researchers, however, have had success with smaller manual and electronic markets in investigating and determining the effects of certain market mechanisms (e.g., price convergence). Information aggregation (accumulation of all required information) is one such topic of study and has formed the basis of many experimental studies into share markets (e.g., O'Brien and Srivastava, 1991).

O'Brien and Srivastava (1991) studied the performance of experienced human traders using a software simulated computerised electronic market with multiple periods and assets. While they found strong evidence against information aggregation, they also found that conventional economic tests were unable to reject the hypothesis of an efficient market (information wise). In summary, they decided there was not sufficient evidence to conclude that the market made efficient use of the information available.

Some argue, however, that the lack of social interaction and trading floor noise has resulted in the loss of information that was otherwise incorporated in the old open outcry prices. That said, with the pervasiveness of the Internet, traders now have much greater access to real-time information flows from multiple sources, be they public (e.g., press releases and company reports) or private (e.g., from a commercial advice service). The title of 'trader' is also no longer limited to professional day traders. There is an opportunity for 'mum and dad' type traders to manage their own portfolios, though with significantly lower levels of education and experience than their seasoned counterparts. Whether all this information can be adequately processed

by novice traders into a form useful for quality decision-making is a matter of contention and is considered in this study.

Brokers are also tied into the stock exchange systems and can electronically place market orders with minimal delay. This allows their trader clients to quickly undertake trades via methods such as a website or mobile phone data service. This opportunity for faster trading has been shown by Odean (1999) and Barber and Odean (2000, 2001, 2002) to be less than beneficial for some traders.

Novice traders, information overload and excessive speed makes for a fiscally dangerous mix. While computers are the catalyst for this shift to screen-based electronics trading, they help mitigate some of its negative effects. Research and practical applications within industry have shown DSSs to be beneficial when appropriately designed for a given task. Despite this, research into financial DSSs that process share value data into aggregate information still appears to be either not considered or unpublished. The reason for this can be attributed to either confidentiality or infeasibility. Nonetheless, this study argues that there is an opportunity to start investigating DSSs. Even fundamental questions about whether cognitive abilities influence financial performance in electronic share trading have not been considered. The reasons for this state of affairs are discussed in the next section.

2.3. Human Decision-Making

The decision-making literature has roots in many different disciplines (e.g., psychology, sociology, statistics and computer science), each with their own perspective of human behaviour (Turban and Aronson, 2001). For many years,

psychologists and behavioural science practitioners have studied how individuals process information to arrive at a particular decision. Historically, some researchers have found human reasoning and decision-making to be deficient when compared to models of human behaviour grounded in logic and mathematics (Anderson, 2005). This is primarily due to an individual's ability to freely adapt their decision-making process in response to influential factors (such as stress, cognitive burden and mental abilities). This adaptability does not always optimise the process, especially when the decision-maker does not have the benefit of hindsight before choosing a course of action (Payne et al., 1993).

Bounded rationality, where humans are portrayed as only partly rational and less than rational at times, is one of the concepts attributed to Herbert Simon (1957). He coined the term 'satisficing' in recognition of the observation that decision-makers are only rational enough to meet a particular goal before reverting to other methods of behaviour (which may not be rational). He felt that by recognising the costs of collecting and processing information, the classical models based on rationality could be made more realistic. Much of this thinking has been applied to economic studies, such as those by Daniel Kahneman, involving rational agent models (Kahneman, 2003).

Financial markets operate according to a similar assumption. Agents operating under the efficient market hypothesis (Fama, 1970) are assumed to be economically rational even while realistically many have bounded rationality. Behavioural finance, a comparatively young discipline, recognises the importance of agent-based models that more accurately reflect the decision-making process. Some share traders will devote

one hour each day to online trading in order to satisfy their expectations of a positive financial outcome. However, how that hour is spent is not necessarily optimised for meeting that goal. Barber and Odean (2002) showed that traders who moved from phone-based to online trading suffered reduced investment performance. They partially attributed this to overconfidence and a failure to recognise the added transaction costs of increased trading frequency even at a lower per trade cost. Put another way, these traders knew what cognitive steps to follow but did so less completely and with an overconfidence bias.

The term 'decision-making' is often synonymous with problem solving, yet the two can be differentiated on the basis of phases within the decision process (Turban and Aronson, 2001). Models for decision-making are typically task specific and involve activities such as outcome weighting and decision trees. Simon's (1960) decision-making model is widely regarded as a classic work in the area. It models decision-making in four phases: i) intelligence, ii) design, iii) choice and iv) review. Huber's (1980) problem solving process builds upon Simon's model with the addition of an 'implementation' stage[1], where the chosen solution is put into effect. This need for implementation is what separates problem solving from the initial decision-making. However, for the purposes of this thesis, the terms 'decision-making' and 'problem solving' are used interchangeably due to a reliance on observing decision-making (speed and quality) through problem solving outcomes (trading actions and financial performance).

[1] Some discussions of Huber's problem solving process include another stage—'monitoring'—where the implementation is evaluated. While this is certainly an important stage, it is not directly relevant to this study because the focus is on aiding the decision-making phase (i.e., the first three stages).

As previously mentioned, Simon's decision-making model consists of four decision-making stages: i) intelligence (identifying and defining the problem), ii) design (developing alternative solutions to the problem), iii) choice (selecting a course of action) and iv) review (reflection on chosen action). The problem itself can vary, from something structured and well-understood to something ill-structured or unstructured and poorly defined. Decision support systems are routinely used by organisations to help employees solve unstructured (and semi-structured) problems by supporting the decision-making process in all three stages.

An integral part of decision-making is the selection of a decision strategy. Decision strategies can be segregated into two different categories: those which consider all available information and choices and make explicit consideration for tradeoffs; and strategies that avoid tradeoffs and prioritise certain pieces of information over others (heuristics). Due to the cognitive limits of the human brain, decision-makers are often unable to process all the available information. Therefore, they adopt a decision approach using heuristics, which in turns leads to do a reduction in decision quality as information is discarded (Payne, 1993). An alternative view is a dichotomous categorisation into compensatory and non-compensatory decision strategies. This is determined by whether pertinent information is discarded from the decision equation (compensatory) or not (non-compensatory).

Chu and Spires (2003) reported that cost-benefit theories of decision strategy, found in studies such as Beach and Mitchell (1978) and Payne et al. (1993), explain a significant amount of human decision-making behaviour. When presented with a selection of decision strategies available for use, the decision-maker weighs the

strategy's accuracy (benefit) against the amount of cognitive effort thought to be required (cost). Whichever strategy provides the most benefit for the least cost is the one chosen, though that choice may change when influential conditions alter. This contingent decision-making behaviour may appear inconsistent (Payne, 1982), but it still maintains the assumption of bounded rationality (March, 1978).

Much of the research concerning cost-benefit theories (e.g., Huber, 1980; Payne et al., 1988) has focused on the development of measures of accuracy (i.e., the benefit) and effort (i.e., the cost). The insights of these studies were deduced from analysis which Chu and Spires (2003) argue to be only partially complete. They argue that the decision-maker's perceptions of accuracy and effort were the better determinant of decision strategy selection (as seen in Payne et al., 1993). Fennema and Kleinmuntz (1995) also concluded that decision-makers only have a limited ability to perceive the accuracy of their decision process and the cognitive effort to be exerted to complete that process. Such perceptions vary as conditions change and other factors, such as overconfidence (e.g., as concluded by Barber and Odean, 2001 for explaining worsening financial performance by day traders), may in fact bias those perceptions (Payne, 1993).

Earlier, Payne (1976) and others proposed that decision-makers use a two-stage process for making decision choices when presented with a range of possible alternatives to select from. The first stage involves the use of non-compensatory decision strategies to reduce decision options and the second stage involves the use of compensatory strategies to finalise the choice. It was argued that the first stage required non-compensatory strategies due to cognitive restraints; decision accuracy

was traded off against mental capability. However, in the second stage, there is a desire to make the most effective use of those cognitive abilities. Therefore, a compensatory strategy is adopted to maximise accuracy.

Cognitive abilities play an important role in strategy selection. It is also important to understand exactly what cognitive abilities and what factors influence decision-making performance for a given level of cognitive ability.

2.4. Cognitive Abilities and Decision-making

Of interest in this study is how individual differences in cognitive ability affect decision-making performance under time pressure. The innate cognitive abilities of an individual determine his or her capacity to learn new skills, create a repository of knowledge and adapt to new situations (Anstey, 1999). They are also a determinant of the individual's ability to perform routine tasks with speed and accuracy (Salthouse, 1985) and competency in the workplace (Kolz et al., 1998; Sackett et al., 1998). A study by Gottfredson (1997) showed that cognitive ability is a reliable predictor of job performance for almost all employees when completing everyday tasks. So far, this study has used the term 'cognitive abilities' in the generic sense to describe the mental processes behind decision-making. However, certain aspects of those abilities can be categorised (e.g., manipulation of objects in working memory and mental arithmetic).

Cognitive ability is not the only influential factor in the choice of an individual's decision-making strategy. Payne (1993) postulated that prior knowledge affects strategy selection on the basis that previous experiences influence choice due to the frequency and recency of previous strategy applications.

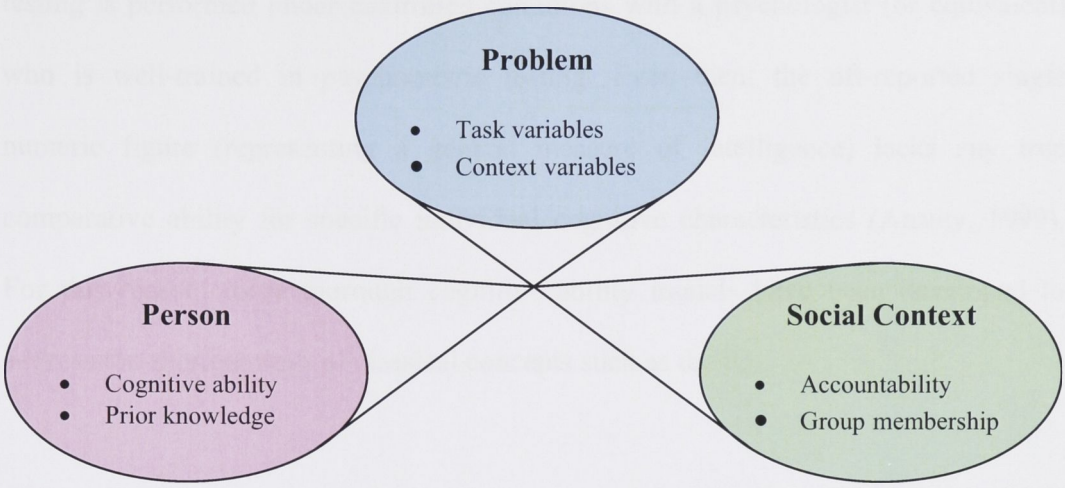

Figure 2-2 - Contingent strategy selection (adapted from Payne et al. 1993)

Other contingencies affect strategy selection. Figure 2-2 shows a modified model from Payne et al. (1993) that takes into consideration the person (i.e., the decision-maker), the problem and the social context in which the decision is formulated. The primary focus of this study is on the individual decision-maker. It examines the influence of different cognitive ability levels when other factors, such as task specific prior knowledge, the problem and social context, are controlled. This study does not directly identify the strategy used by the decision-maker (neither decision nor trading). It is expected that decision-makers change strategy as they reach their cognitive limit for the current strategy choice. The presence of a decision aid is expected to allow greater decision quality within the decision-maker's cognitive limit, resulting in a positive effect on trading (i.e., financial) performance.

For many people, cognitive ability is synonymous with how smart an individual is. This is reflected in the widespread use of the intelligence quotient (IQ) by members of

the general public. However, the validity of the IQ concept is questionable unless testing is performed under controlled conditions with a psychologist (or equivalent) who is well-trained in psychometric testing. Even then, the oft-reported single numeric figure (representing a general measure of intelligence) lacks any true comparative ability for specific individual cognitive characteristics (Anstey, 1999). For this reason, more thorough cognitive ability models have been developed to address the shortcomings of classical concepts such as the IQ.

One such comprehensive model is based upon research by Horn (1982; 1985; 1987; 1994) which was a continuation of the prior work by Cattell (1941; 1971). It provides a hierarchical framework for understanding cognitive abilities. The Cattell-Horn-Carroll (CHC) model places general mental ability (GMA) at the top of the structure and two broad domains of intellectual functioning—fluid and crystallised abilities—below it.

The theory of fluid and crystallised abilities postulates that a range of abilities influence performance rather than a single IQ-like measure. There is an overlap between crystallised and fluid abilities. Both share characteristics in the processes of perceiving relationships, logical reasoning, abstraction, concept formation, problem solving and the like. A range of other broad abilities play a part in human performance by contributing to either fluid or crystallised ability. These are broad visual ability, working memory, long-term memory, cognitive speed and quantitative knowledge. Given individual differences in fluid and crystallised abilities, some people are better at processing information for tasks than others.

The concept of fluid ability is similar to the concept of 'raw' ability—the innate reasoning ability that people have regardless of the culture into which they are born. Fluid abilities develop as the brain matures neurologically and start to diminish in middle to late adulthood.

Crystallised ability is the general knowledge of facts, strategies and skills that are the result of education, training and experience. Individuals develop this knowledge during their lifetime. It is often referred to as 'wisdom' in older people.

Cognitive ability is expected to be a significant predictor of work performance (Anstey, 1999). Carroll (1993) found that individuals with high fluid ability tend to have better working memory and are faster at problem solving. This advantage should manifest in a time constrained environment, where decision-makers with higher fluid ability can 'out-think' their competitors to improve their financial performance. Similarly, crystallised ability in the form of verbal skills (necessary for processing informational cues) should also be associated with higher levels of performance in share trading in the time constrained environment.

The CHC model also includes a range of broad mental abilities: quantitative knowledge, broad visual ability and cognitive speed. Of these three, quantitative knowledge is of most interest as it reflects the mental mathematical abilities of the decision-maker. For share trading, quantitative knowledge is expected to be particularly pertinent to performance. If mental arithmetic is an influencing factor, higher levels of quantitative knowledge should result in higher calculation quality

and, therefore, higher financial performance. The above arguments result in the following three hypotheses:

H1a: *A higher level of fluid ability will lead to higher performance in financial trading by novice traders.*

H1b: *A higher level of crystallised ability will lead to higher performance in financial trading by novice traders.*

H1c: *A higher level of quantitative knowledge will lead to higher performance in financial trading by novice traders.*

2.5. Rapid Decision-making

The decision-making process can be context dependent. The process relies on factors both internal (e.g., time pressure) and external (e.g., time constraints) to the decision-maker. Reduced performance is expected when there are time constraints because a decision-maker is likely to engage in non-compensatory rather than compensatory decision-making. Compensatory processes tend to involve all available information in the decision process whereas non-compensatory processes involve only a portion of the total available information (Payne et al., 1993). A study by Hogarth (1987) found that compensatory processes may lead to decisions of higher quality but at the cost of increased cognitive load.

Before further discussion of the effects of time, it is important to note that the use of the terms 'time constraint ' and 'time pressure' are often used interchangeably in the literature (Svenson and Maule, 1993). For the purposes of this study, the two concepts are different, following Ordonez and Benson (1997):

- Time constraint – A deadline or time restriction imposed upon a task when the decision-maker has a limited amount of time in which to make the decision. This constraint is often fixed to a particular value for experimental purposes, either arbitrarily or based on previous findings.

- Time pressure – The stress induced as a result of a time constraint on a human decision-maker. It is possible to have a time constraint but not time pressure if the decision-maker can arrive at a decision within the time constraint period.

Numerous empirical studies have concluded that time pressure has a significant impact on decision strategy (Ben Zur and Breznitz, 1981; Wright, 1974; Zakay and Wooler, 1984) and effectiveness (Peters and O'Conner, 1980; Peters et al., 1984). Wright (1974) found that decision-makers adopt simplified strategies when time pressure is high and place greater emphasis on negative information for decision alternatives. Ben-Zur and Breznitz (1981) also found their experimental participants focused more upon negative information and preferred less risky alternatives under time pressure. Research by Zakay and Wooler (1984) supported Wright's (1974) findings. These researchers also found that as time pressure increased, decision quality decreased. A reduction in decision quality was also observed by Payne et al. (1993; 1995). Other effects considered to be a result of time pressure are a move towards less extreme judgements (Kaplan et al., 1993) and a reduction in risk propensity (Ben-Zur and Breznitz, 1981). Studies have found as a secondary result that time constraints appear to have a negative influence on decision-making (Kerstholt, 1994; Rothstein 1986; Wallsten & Barton, 1982).

However, not all studies have produced similar results. For example, Svenson and Benson (1993) found that framing bias weakened under time pressure, indicating an increase in decision quality. These results prompted Maule et al. (2000) to investigate the factors producing these contradictory findings. They identified three important issues arising from studies by them and other researchers.

1. Typically, time pressure is treated as just another task characteristic without consideration for changes in affective state, which changes the type and quality of decision-making. With the inclusion of a time constraint (i.e., deadline), numerous affective states may arise depending on the decision-maker's perceived ability to maintain task performance to meet goals and the level of importance he or she places upon each decision (Maule and Hockey, 1993). This is where the distinction between time constraints and time pressure starts to blur. Maule et al. (2000) refer to a pressure state, where individuals can adapt their cognitive strategy to maintain task goals, and a stress state, where they cannot.

2. Time pressure effects evolve as the individual's method of adapting changes. Maule and Edland (1997) posit that decision-makers under time pressure make micro changes in strategy (e.g., filtration and acceleration) or a macro change in the decision rule (e.g., from compensatory to non-compensatory). There can also be a change in the prioritisation of information processing, with information processed further (Ben-Zur and Breznitz, 1981), or in the weighting of certain information categories (Wright, 1974).

3. The actual task structure can play an important part. Studies with different task structures produced different results. Busemeyer and Townsend (1993) showed that in a risk-taking gambling scenario, time pressure effects depended on the probability changes and whether the expected outcome values were positive or negative.

Chu and Spires (2001) stated that a failing in current decision support (DSS) research is that decision-makers are granted virtually unlimited time to perform tasks. This time freedom is at odds with the real-world, where decision-makers tend to be under time pressure in their decision-making process, though the time constraint varies according to task and environmental conditions. This gap in DSS research has been partially addressed in decision-making research. Payne et al. (1996), Stern (1999) and Verplanken (1993) focused on shorter time constraints (i.e., less time available for decision-making). Stern (1999) found a significant difference in performance between 25 seconds and 5 seconds, with the latter time making the subjects feel that the time restriction affected their decision-making. There was no significant difference between 25 seconds and 10 seconds and between 10 seconds and 5 seconds in this study.

In the share trading environment, there is a limited amount of time for decision-making. A trader who chooses to trade more often decreases his or her time availability. The Financial Trading System (FTS) used in this study provides an interface and trading environment similar to that of real-life systems, such as the Stock Exchange Automated Trading System (SEATS) used at the Australian Stock

Exchange. Barber and Odean (2002) found that traders traded more actively when using online systems than when using the phone. In this case, the time constraint is self-imposed rather than imposed by external conditions. It is believed that the more trading actions performed by each individual within a time period, the worse his or her performance, possibly due to a shift towards a non-compensatory decision process. As cognitive abilities govern decision capability, rapid decision-making and cognitive ability are closely tied together.

In this study, the number of trading actions is used as a proxy for decision speed. It is expected that the more trading actions performed by each individual within a time period, the higher the speed of each decision and the worse the performance of the novice trader (possibly due to a shift towards a non-compensatory decision process). This leads to the following hypothesis:

H2: *Higher decision-making speed will lead to lower performance in financial trading by novice traders.*

2.6. Decision Support Systems

A computerised DSS has the ability to manipulate a large amount of information, produce reports in a flexible task-specific format, access different customisable analysis methods, support different decision-making frequencies and give the option of optimisation, satisficing and heuristic approaches. These capabilities, if utilised effectively, should provide a higher decision quality for the same (or lower) level of cognitive effort. Alternatively, the cognitive resources freed by the DSS can be used to expand the range of decision strategies available, some of which previously may have been prohibitively expensive (in the cognition sense). Sharda et al. (1988),

however, highlighted that in some cases the use of a DSS does not always increase decision effectiveness, efficiency and quality.

DSSs were originally defined as a 'model-based set of procedures for processing data and judgements to assist a manager in their decision-making' (Little, 1970, p. 470). They have evolved over time as information processing capability has increased. Moore and Chang (1980) argue that whether the problem is structured or unstructured is unimportant. Indeed, DSSs should be capable of supporting ad hoc decision analysis and modelling. Additionally, this support should be available at irregular and unplanned intervals to support future planning. Alter (1980) proposed that effectiveness over efficiency and flexibility, instead of consistency, distinguishes a DSS from traditional electronics data processing (EDP) systems. This focus on flexibility highlights the importance of designing decision aid tools that address underlying individual decision-making characteristics rather than solve the problem by suggesting a rational solution derived solely from the systems knowledge base.

Because task specificity is integral to their design, DSSs exist in a wide range of forms. However, from their conception to the present, DSSs have had many common characteristics (Marakas, 1998). Without consensus on what a DSS is, there has been no agreement on its standard characteristics and capabilities. Instead, Turban and Aronson (2001) postulate a list of major capabilities for a DSS (see Figure 2-3).

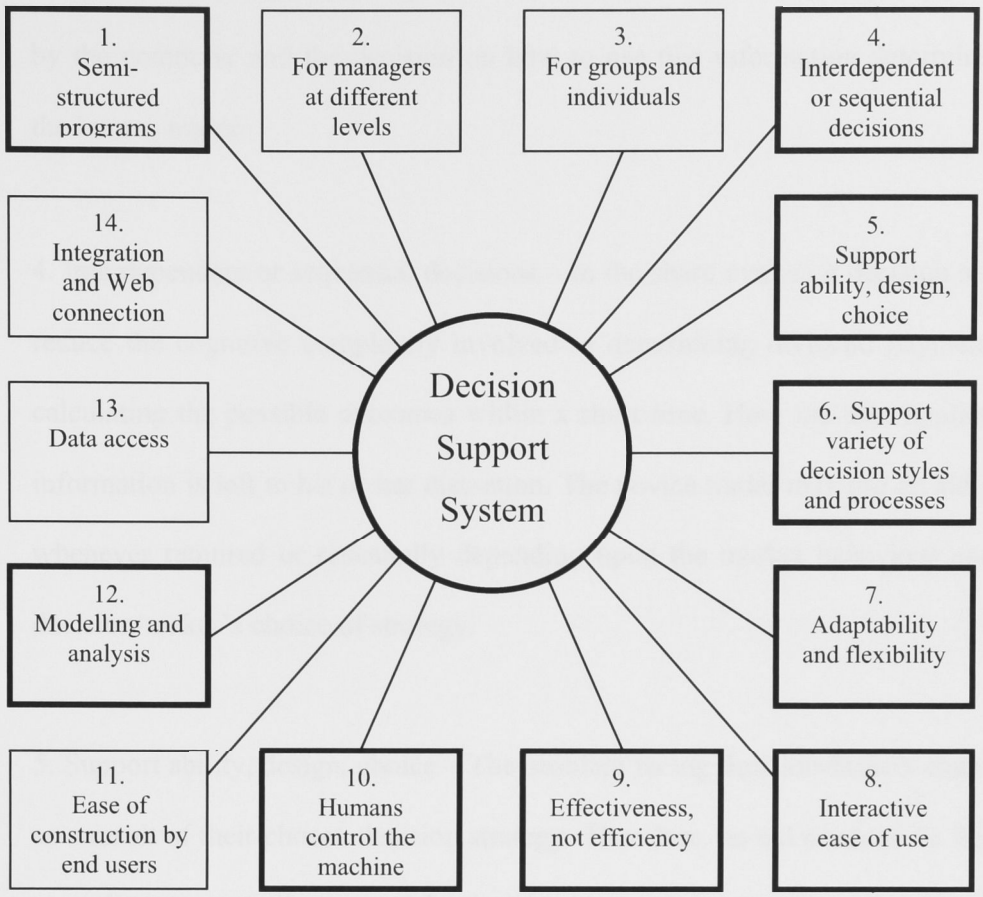

Figure 2-3 - The Ideal Characteristics and Capabilities of a DSS (adapted from Turban and Aronson, 2001)

Each capability highlighted in bold in the above diagram will now be explained and its application to the share trading environment, where relevant, noted.

1. Semi-structured programs – Decision support is provided to the decision-maker in a way that combines the computerised information (i.e., share market data) with human judgements based upon interpretation of that information. This is done with the premise that, by itself, the system is unable to solve the semi-structured/unstructured problem (i.e., the aid enhances the quality of the decision that can only be performed by the human). Within the share market, the

computationally expensive cognitive calculations of share value can be performed by the computer and the decision on how to use that information determined by the human trader.

4. Interdependent or sequential decisions – In the share market, a decision aid can reduce the cognitive complexity involved in determining dividend payments by calculating the possible outcomes within a short time. How the user applies this information is left to his or her discretion. The novice trader may use an aid once, whenever required or repeatedly depending upon the market behaviour and the decision-maker's choice of strategy.

5. Support ability, design, choice – The problem facing decision-makers can differ as a result of their chosen decision strategy. Therefore, an aid needs to be flexible enough to support all stages of the decision process by enhancing data common in each stage.

6. Support a variety of decision styles and processes – Rather than prescribe a set train of thought, an aid should provide information that supports multiple strategies and decision-making styles.

7. Adaptability and flexibility – Not all decision-makers follow a consistent course of action. Individuals may tweak decision efficiency for repetitive tasks. An aid needs to provide flexibility to adapt as the decision-maker adapts to the task.

8. Interactive ease of use – If a decision aid aims to reduce a decision-maker's cognitive burden or increase information processing capabilities, it would be counter-productive for it to place further strain upon already taxed cognitive limitations.

9. Focuses on the effectiveness, not efficiency, of the decision-making process – It could be argued that the most efficient decision-making aid only requires a yes or no response from the user regarding the best course of action. Minimising the choices to be considered would provide a speed advantage over other novice traders, who would need to engage in further cognitive processing to arrive at a decision.

10. Humans control the machine – Some humans have difficulty trusting decisions made by devices they do not fully understand. When significant amounts of time and resources are involved (particularly money), the aid may function best by building trust over time without dictating the course of action (unless unavoidable).

12. Utilises underlying data and models – Each novice trader is provided with random dividend payment data. A decision aid can process the data to calculate useful information. This information is then communicated to the human user so that he or she can incorporate this new knowledge into the decision-making model currently being used.

Studies investigating the effects of decision support on share trading are limited to the use of graphs and indicators showing historical information (e.g., volume weighted average prices and market indicators). One of the few related studies was a partial match to a business simulation by Sharda et al. (1988) which involved investment decisions and uncertain economic conditions. They showed (as expected) that decision-makers with access to a DSS made significantly more effective decisions than their counterparts who lacked a DSS. Interestingly, the DSS users took longer to make their decisions. After repeated usage, however, their times converged.

2.7. Decision Support in Share Trading

The foregoing discussion leads to a secondary research question for this study:

> *Do novice share market traders with a decision aid perform better than traders without an aid?*

It is expected that a decision support tool will help a novice trader make a more rational decision rather than one based purely on limited experience and 'gut reactions'. By supporting the fundamentals of share pricing, it is proposed that novice traders using a decision aid will have a financial performance benefit over novice traders without similar cognitive support. This enhancement to their decision-making ability will allow greater levels of multitasking because more memory intensive calculations will be simplified and cognitive resources may be allocated to other tasks as necessary.

A correctly designed decision aid will enhance the inherent cognitive abilities of a decision-maker. If the decision-maker lacks formal training or experience in how to manipulate the available information, the decision aid will improve decision quality (for as much as it is designed to encompass). This results in a third hypothesis:

> **H3**: *The use of a decision aid by novice traders will lead to their higher performance in financial trading.*

Although the availability of decision support is expected to result in improved financial performance for all novice traders who use it, it is expected that it will be most beneficial to novice traders with limited cognitive abilities (i.e., fluid and crystallised abilities, and quantitative knowledge) for reasons outlined earlier. This results in the following hypotheses:

> **H4a**: *A decision aid can mitigate the detrimental effects of lower fluid ability on financial trading performance by novice traders.*
>
> **H4b**: *A decision aid can mitigate the detrimental effects of lower crystallised ability on financial trading performance by novice traders.*
>
> **H4c**: *A decision aid can mitigate the detrimental effects of lower quantitative knowledge on financial trading performance by novice traders.*

Similarly, it is expected that decision support can enable novice traders to trade more quickly without suffering the negative effects of cognitive overload and resultant errors or lapses in judgement. This is reflected in the following hypothesis:

> **H5**: *A decision aid can mitigate the detrimental effects of higher trading speed on financial trading performance by novice traders.*

2.8. Research Model Overview

The EMH is not complete because it cannot model the influence of traders, particularly novice traders. The reason for this is that while opportunities exist for a decision-maker (e.g., a practitioner, investor or trader) to make an irrational decision, there also exists a need to measure the effects of the decisions made.

The strength of behavioural finance is its ability to highlight the limits of human reasoning and their effect on decision-making. While it may be human to err, it is also human to seek a solution to reduce or remove the negative effects of mistakes. The quality of a solution to a problem is a function of the speed at which a decision can be made and the quantity of the cognitive resources available to make it.

A person's cognitive ability will influence his or her ability to retrieve and process information. People with a higher level of cognitive ability should be able to make decisions of higher quality, on average, than people with a lower level of cognitive ability (**H1**).

As decision-making speed increases (i.e. the time available to make a decision decreases), the timeliness of the decision to be made becomes more important. The time may be sufficient for a full consideration of the information at hand, but eventually the time allowable will be compressed to the point where a compensatory decision-making process is adopted and quality is reduced (**H2**).

More often than not, computers are relied upon to supplement human inabilities or even automate a process, thereby removing the human factor. As complex financial markets cannot be accurately modelled with a computer, it is still desirable to have a human operator ultimately deciding financial decisions. The computer becomes a tool in the true sense of the word—a tool to be used as the human deems fit. The tool can be a relatively simple calculator that allows complex calculations when in the hands of an experienced and knowledgeable user. The tool may also be a table of important values or a graph showing historical information. The value of the tool lies in finding a balance between its form and function.

A decision aid can reduce the cognitive burden on novice traders forming initial pricing valuations. The decision tool used in this thesis draws upon the design of FTS (Financial Trading System) to ensure a level of immediate familiarity by the user. With aid use, decision quality and, therefore, overall financial performance should improve (**H3**).

The decision aid by itself is not a miracle tool that makes every decision better to the same degree. It also cannot give every user the same benefits. What it can do is provide more equal guidance regarding fundamental prices. The final impact of the tool is determined by the person's decision-making speed (**H2**) and cognitive abilities (**H1a, b, c**). Figure 2-4 portrays a diagrammatic model of the five hypotheses.

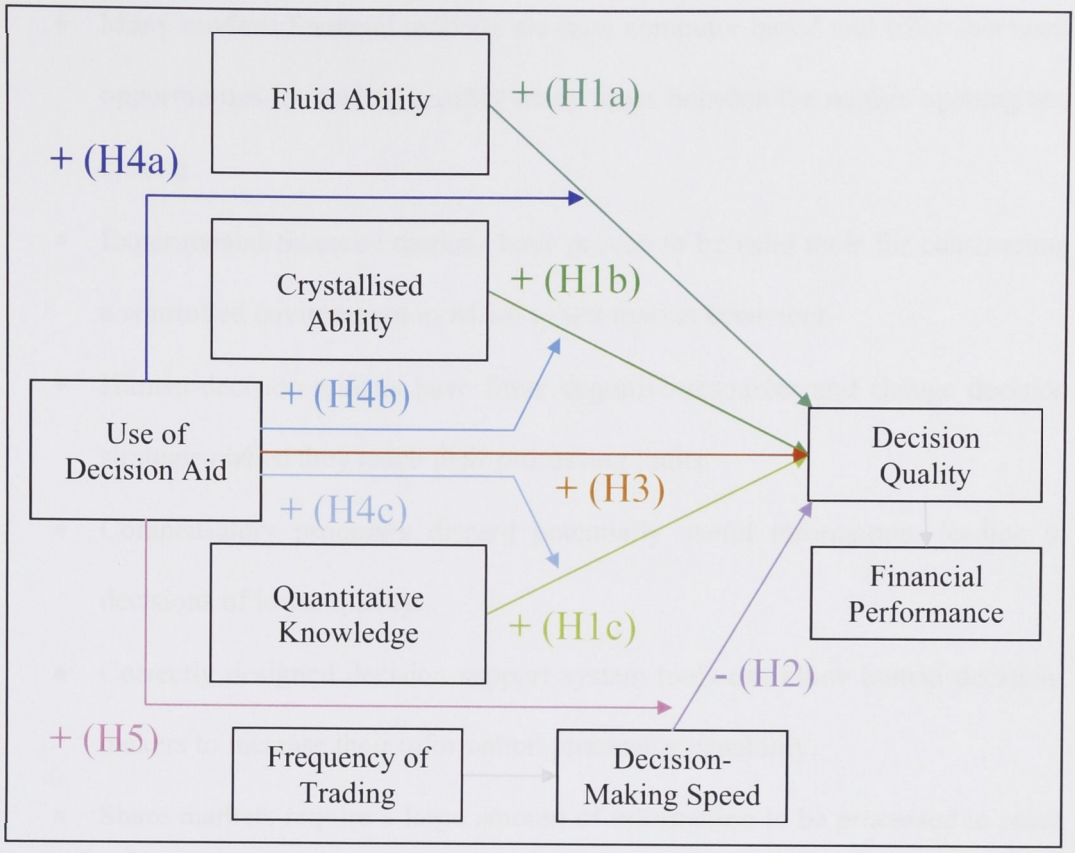

Figure 2-4 - Research Model

2.9. Chapter Summary

This chapter has reviewed the research literature on financial markets, decision-making, cognitive abilities and their relationship with decision-making and decision support systems that supplement or support rapid decision-making. The following conclusions were drawn:

- Traditional finance treats share traders as rational decision-makers who have, and make use of, all information available to them.
- Behavioural finance accepts that humans are not always rational and that personality traits play a part in explaining trading performance.

- Many modern financial markets are now computer-based and offer increased opportunities for trading quickly many times between the market opening and closing.
- Experimental financial markets have proven to be valid tools for constructing a controlled environment in which to test market behaviour.
- Human-decision makers have finite cognitive resources and change decision strategies when they reach their processing limits.
- Compensatory processes discard potentially useful information, leading to decisions of lower quality.
- Correctly designed decision support system tools can allow human decision-makers to increase their information processing capability.
- Share markets require a large amount of information to be processed to reach an accurate share price.
- Decision aids can better equip a human decision-maker by offloading certain structured tasks to an external processor (i.e., a computer).

Five main hypotheses were identified for investigation in a financial trading context. A research model was developed to illustrate the relationship among the constructs involved. The hypotheses considered in general terms for novice traders are:

1. Higher cognitive abilities will lead to higher financial performance.
2. Higher decision-making speed will lead to lower financial performance.
3. The use of a decision aid will lead to higher financial performance.
4. A decision aid will help reduce any negative effects of low cognitive abilities.
5. A decision aid will help reduce any negative effects of high trading speeds.

The method used to test these hypotheses is discussed in the next chapter.

Chapter Three
Research Methodology

'Though this be madness, yet there is method in 't.'
– Shakespeare [*Hamlet* (II, ii, 206)]

3.1. Introduction

Two experiments using the same design (Chapter 4 and 5) were undertaken in this study. This chapter contains an overview of the methods common to both studies (procedures, instruments and ethical considerations). Details specific to each experiment will be discussed in the respective chapter.

3.2. Justification for the Methodology

Yin (1994) recognised that research methods do not have to be purely quantitative or qualitative and that the design depends upon the data to be collected. Quantitative methods generally have stronger internal and external validity but their results may be less generalisable to real-world contexts when external environments can't be completely modelled. On the other hand, qualitative methods can suffer a lack of external validity and only focus on internal generalisations. Due to the concepts involved (decision making speed, cognitive abilities and decision aid support), an experimental approach would be most suitable. Other methods may be suitable, but only in smaller investigative roles. Table 3-1 shows a breakdown of typical research methods and provides a description and example of each method.

Method		Description	Example(s)
Quantitative	Experiment	Apply treatment, measure results (before and/or after) and determine causal relationship between variables (if any) – traditional scientific investigation	Determining boiling point of water at different altitudes
	Historical Data	Examine previously collected data for patterns/trends	Predicting direction of property value change
	Survey	Ask closed questions and gather responses	Census demographics
Qualitative	Action Research	Apply an idea in practice and then evaluate the results to determine how to modify the idea.	Prototyping user interfaces
	Case Study	Study a real-life situation and understand it from a holistic perspective	Organisational knowledge flows
	Survey	Ask open-ended questions and gather responses	User opinions of system success

Table 3-1 - Research methods (adopted from Yin, 1994)

The process of observing phenomena in a controlled environment is 'experimentation' (see Kaplan, 1964). Nagel (1961) defines scientific observation as 'controlled investigation'. The concept of a 'test' embodies what an experiment is. A researcher deliberately manipulates a treatment(s) within an experiment to test its causal outcomes. For this to occur, a comparison is required between those objects or participants that received the experimental treatment and those which did not (i.e., the control group). Through random assignment, the ability to distinguish the effects caused by the treatment is further strengthened (Cook and Campbell, 1979).

Experimental markets are being used increasingly to investigate specific market microstructure questions.[2] Bloomfield and O'Hara (1999, 2000) used experimental markets in research on market microstructure to focus on particular aspects of market behaviour that are difficult to identity using historical trade-by-trade data. Flood et al. (1999) also used experimental markets to analyse the impact of quote disclosure on price discovery.

The market microstructure literature is extensive and dates back at least to Adam Smith's *An inquiry into the nature and causes of the wealth of nations* (1776). Since the 1990s, the development of electronic markets has increased due to numerous advances in technology and the computational power for enabling such markets. The electronic simulation of markets, using computer-based market maker software, allows the environment to be controlled through the limiting of external influences. This increased level of control allows researchers to alter agent behaviour and gather data with limited, or no, external influences.

The results of studies using experimental markets suffer from a generalisability problem due to their 'clean room' nature and strict controls. (External validity is sacrificed for an increase in internal validity.) It is not feasible to attempt to model a stock market such as the ASX or the NYSE because of their complexity (Franci et al., 2001). That complexity could also possibly complicate the observation of beneficial effects expected from client aids, such as decision support tools. Although the use of an experimental market means that the ability to replicate a large market in its natural

[2] The study of market microstructure involves an analysis of the impact of the market on prices at the trade-to-trade level. It includes an analysis of the determinants of the bid-and-ask spread and focuses on the way that market features as well as information affect prices as trading unfolds throughout the trading day.

state is lost, the ability to closely study the effect of a decision aid at the individual level is gained.

Earlier automated electronic market experiments, such as the one conducted by Williams (1980), were relatively simple. Over time more complex markets that allow more choice in variable control and provide extra features to support dynamic markets with various capabilities have been developed (O'Brien and Srivastava, 1991). The experimental markets used in this study are of the continuous double auction (CDA) type, where buyers and sellers are free to accept any offer or offer a sale to any other trader. Short-selling and borrowing are enabled to allow behavioural freedom and encourage the maximisation of profit earnings.

The experimental market is not able to capture the human aspects of trading. As such, paper-based questionnaires were used to record levels of participant confidence, trust and understanding. A web-based testing suite was used to determine the cognitive abilities of each novice trader.

3.3. Experimental Materials

3.3.1. Market Simulation

The real-time trading software package used was the Financial Trading System (FTS) (http://www.ftsweb.com), which was developed by OS Financial Trading System and is described in O'Brien and Srivastava (1991). It is used to create experimental financial trading markets. The system provides participants with trading experience in a simple market environment. It consists of four components: the server software (ftsMarket), clients (ftsTrader), a trading case (Microsoft Excel spreadsheet) and the

data output file (flat text file, Microsoft Excel spreadsheet or Microsoft Access database).

FTS models a continuous double auction. The double auction (DA) has been investigated in experiments conducted since the early 1960s (Smith, 1962) and is believed to be an efficient competitive trading environment that closely resembles the modern stock market. It is impractical to attempt to model a real-world stock market, so the choice of a simulated CDA market allows increased generalisability to an environment with similar interfaces and mechanisms. Electronic markets have found to be useful tools as trading game simulations in the classroom. Previous studies by Foster et al. (2004, 2006) using a similar experimental market found that the participants believed they benefited from using a trading game environment (FTS Trading System). They reported a positive attitude towards its use and a feeling that they had learned something from the experience beyond the theoretical study within normal coursework. These benefits are aligned with the results of other research investigating the use of simulation in the classroom (Ball and Holt, 1998; Frank, 1997; Helliar et al., 2000; Kagan et al., 1995; Sachdeva, 1989).

The 'market efficiency' trading case (RE1) used in this study is the simplest of a comprehensive set of market games supplied by OS Financial Trading Systems. Through an Excel spreadsheet, it is possible to control almost every aspect of the experimental market simulation. Table 3-2 to Table 3-6 show the configuration settings for each major configuration. The experiments discussed in Chapter 3 and Chapter 4 both make use of the FTS, though the experimental design was manipulated through slightly different market settings and a change in the method for

communication of private information. The following explanation of the FTS uses the configuration from Experiment 1.

The values in Table 3-2[3] control the overall mechanics of the market. Up to 60 traders (dependent on server configuration and market activity) were able to trade two securities (shares) for a maximum of 8 trials. Each trial consisted of two 300-second (5-minute) periods. Participants were alternately assigned to one of two trader types that governed their starting position and were provided with one of nine pieces of private information. The market limit order book depth was set to 10, with the top five visible. Traders were able to borrow unlimited amounts of money.

Number of Securities	2
Maximum Number of Trials	8
Number of Periods per Trial	2
Period Length (seconds)	300
Maximum Number of Traders	60
Number of Trader Types	2
Market Depth	10
Depth Displayed	5
Borrowing Allowed	Yes
Last Row with Exogenous Prices	
Number of Information Types	9
Last Row with Information	36
Recalculate	No

Table 3-2 - RE1 Market Configuration

Table 3-3 shows the variables that define each security type. Both ABC and CRA are stocks that live for a length of one trial (two periods) and do not carry over to the next trial. Both securities may be short sold. This means that a trader could sell shares he

[3] The use of background colour in Table 3-2 to Table 3-6, Table 4-1 to Table 4-5 and Table 5-1 to Table 5-5 is the same as how they appear within the MS Excel spreadsheet that configures the FTS market server. The colours aid in grouping the numerous configuration settings that are tiled across many rows and columns.

or she did not yet own, thus creating a liability to return the shares at some future time. Further, private information about market conditions is communicated to the trader. This provides an information based incentive for trading to take place among the participants.

Name	ABC	CRA
Security Type	Stock	Stock
Price Quotes	Endogenous	Endogenous
Start Life	1	1
End Life	2	2
Short selling	Yes	Yes
Quote to Price Formula	Quote	Quote
Information	Yes	Yes

Table 3-3 - RE1 Security Configuration

The contents of Table 3-4 denote the starting position for each trader type. Traders designated 'Type 1' are endowed with 3,250 monetary units (i.e. $) and 75 units of CRA. 'Type 2' traders, however, receive 750 monetary units, 75 units of CRA and 100 units of ABC. These starting positions are randomly assigned across participants and trials. These allocations rely on multiple trading trials to remove the bias effects so are not ideally suitable for single trial experiments without careful data analysis.

Trader Data	Type 1	Type 2
Cash	3250	750
Endow 1	0	100
Endow 2	75	75
Rights 1	0	0
Rights 2	0	0
Lower Bound	-100000000	-100000000
Lower Bound Payoff	-10000	-10000
Upper Bound	100000000	100000000
Upper Bound Payoff	10000	10000
Constant	0	0
Linear Coefficient	0.0001	0.0001
Quadratic Coefficient	0	0
Log Coefficient	0	0
CARA Coefficient	0	0
CARA Exponent	0	0
HARA Coefficient	0	0
HARA Exponent	0	0

Table 3-4 - RE1 Starting Position Configuration

Table 3-5 shows the dividend payoffs derived from a random condition generator. Depending on the market conditions for each security, spreadsheet macros fill different values into each of the cells. For example, in Trial 5, the dividend payoff for Period 1 would be 24 and 12 (for ABC and CRA respectively). For the sake of mathematical simplicity, the interest rate was set to 0 per cent, so the monetary unit value did not fluctuate over time. A 0 per cent interest rate also removes the need to apply cognitive resources to interest consideration tasks when forming a price valuation.

Payoff and Settlement Data	Stock 1	Stock 2	Interest Rate
Trial 1	0	24	0
Period 2	12	8	0
Trial 2	12	12	0
Period 2	0	8	0
Trial 3	12	0	0
Period 2	24	18	0
Trial 4	12	12	0
Period 2	24	12	0
Trial 5	24	12	0
Period 2	24	18	0
Trial 6	24	12	0
Period 2	12	8	0
Trial 7	24	24	0
Period 2	24	12	0
Trial 8	24	12	0
Period 2	12	8	0

Table 3-5 - RE1 Payoff Configuration

All the private information and dividend payoff amounts are derived from the Trading Case 'work area', as shown in Table 3-6.

Work area			
S1 draws	S2 Draws	S1 Payoff	S2 Payoff
1	4	0	24
3	1	12	8
2	3	12	12
1	2	0	8
2	1	12	0
3	4	24	18
2	2	12	12
3	3	24	12
3	3	24	12
3	4	24	18
3	3	24	12
2	2	12	8
3	4	24	24
3	3	24	12
3	2	24	12
2	2	12	8

Table 3-6 - RE1 Private Information & Payoff Configuration

The 'draws' values within Table 3-6 are the randomly generated seeds for each security. These are passed to Excel macros and determine the appropriate payoff values and the nine appropriate pieces of private information (see 0) for each security.

Market participants have limited information about the dividend payments, so they must use the information given to them as well as the information provided in the reported share prices to determine the actual value of the shares. Equally likely events affect each security. The dividend possibilities for ABC and CRA to be paid at the end of each period are shown in Table 3-7.

Firm ABC		Dividend Period 1	Dividend Period 2
Event x	Poor economic conditions, labour strike	0	0
Event y	Poor economic conditions, no strike	12	12
Event z	Fair economic conditions, good labour relations	24	24

Firm CRA		Dividend Period 1	Dividend Period 2
Event w	Poor economic conditions, labour strike	0	8
Event x	Poor economic conditions, no strike	12	8
Event y	Fair economic conditions, no strike	12	12
Event z	Fair economic conditions, good labour relations	24	18

Table 3-7 - Dividend Payment Possibilities

Those same possibilities can be displayed an alternative way, such as a table which rearranges the information into a matrix format showing the nine possible combinations (as shown in Table 3-8 and Table 3-9 for ABC and CRA respectively). This is the first step towards a relatively simple paper-based decision aid utilising these tables as mental 'scratch-pads'.

ABC		Period 2 Event		
		X	Y	Z
Period 1 event	X	0,0	0,0	0,12
	Y	12,0	12,12	12,24
	Z	24,12	24,12	24,24

Table 3-8 - Dividend Determination Table for ABC

CRA		Period 2 Event			
		W	X	Y	Z
Period 1 event	W	0,8	0,8	0,12	0,18
	X	12,8	12,8	12,12	12,18
	Y	12,8	12,8	12,12	12,18
	Z	24,8	24,8	24,12	24,18

Table 3-9 - Dividend Determination Table for CRA

The participants were instructed in their training sessions how to utilise these tables for determining the dividend payoffs. For example, a participant could be provided with private information that said 'Per 1: Not Y, Per 2: Not Z' for ABC. This would mean that some possibilities could be removed because the participant now knows that the Y event row (Period 1) and Z event column (Period 2) can be eliminated. The participants were trained to cross off the impossible combinations, which resulted in a working model similar to the one depicted in Table 3-10.

ABC		Period 2 Event		
		X	Y	Z
Period 1 event	X	0,0	0,0	~~0~~,12
	Y	~~12~~,0	~~12~~,12	~~12~~,24
	Z	24,12	24,12	~~24~~,24

Table 3-10 - Table with 'Per 1: not Y, Per 2: not Z' possibilities removed

This leaves only four possible outcomes: XX (0,0), XY (0,0), ZX (24,12) and ZY (24,12). From those four combinations, the value calculations for ABC in Period 1 are:

- Minimum Value = 0 + 0 = 0
- Maximum Value = 24 + 12 = 36
- Expected Value = (0+0 + 0+0 + 24+12 + 24+12) / 4 = 18

The minimum value is the least amount that ABC can be worth while the maximum value is the most that ABC can be worth. (It would be irrational to pay more than this value.) The expected value is the weighted average, which gives an equal chance of breaking even.

At the start of Period 2, the participant receives further information. Continuing with the example, it could look like 'Per 1: Z, Per 2: Not Z'. This means that two further possibilities can be removed and the participant is left with ZX (24,12) and ZY (24,12), as shown in Table 3-11.

ABC		Period 2 Event		
		X	Y	Z
Period 1 event	X	~~0~~,0	~~0~~,0	~~0~~,12
	Y	~~12~~,0	~~12~~,12	~~12~~,24
	Z	~~24~~,12	~~24~~,12	~~24~~,24

Table 3-11 - Table with 'Per 1: Z Per 2: not Z' possibilities removed

As this is Period 2, the dividend payment for the period has passed. Therefore, only the second value in the pairs 24,12 and 24,12 is used to determine possible values for

ABC. This means the value is 12 or 12, which results in the only possible value for ABC being 12. This participant knows the actual price in the second period and can trade on this information with an advantage over other participants who are not so well-endowed with information.

Figure 3-1 shows the instructional handout provided to participants to assist in the share valuation explanation.

How to Value a Share in FTS

Refer to Dividend Determinant Sheet as this is explained

Normal Dividend Payment Table

ABC		Period 2 Event		
		X	Y	Z
Period 1 event	X	0,0	0,0	0,12
	Y	12,0	12,12	12,24
	Z	24,12	24,12	24,24

Period 1 Information

Private Information in Excel

ABC private information is:	
Period 1: Not	y
Period 2: Not	z

ABC		Period 2 Event		
		X	Y	Z
Period 1 event	X	0,0	0,0	0,12
	Y	~~12,0~~	~~12,12~~	~~12,24~~
	Z	24,12	24,12	24,24

Minimum Value = 0+0 = **0**

Maximum Value = 24+12 = **36**

Exp Value = $\frac{0+0+0+0+24+12+24+12}{4}$ = **18**

Period 2 Information

Private Information in Excel

ABC private information is:	
Period 1:	z
Period 2: Not	z

ABC		Period 2 Event		
		X	Y	Z
Period 1 event	X	~~0,0~~	~~0,0~~	~~0,12~~
	Y	~~12,0~~	~~12,12~~	~~12,24~~
	Z	~~24~~,12	~~24~~,12	~~24~~,24

Minimum Value = 12 = **12**

Maximum Value = 12 = **12**

Expected Value = $\frac{12+12}{2}$ = **12**

Figure 3-1 - Training sheet used when explaining dividend payments

Each of the participants in the market receives similar levels of incomplete information. Holistically, sufficient information is made available across all participants in the experiment to identify exactly what the value of the share is. In

certain circumstances, such as the previous example, some participants will have complete information in Period 2.

Security CRA differs from ABC in that CRA has four events and, therefore, 16 value combinations. Even when a row and column are removed, there still remain nine possibilities, and a significantly higher amount of valuation decision-making is required. Security ABC is seen as the simplest by most participants, leading to a higher trading frequency. Further details of the RE1 Trading Case and many others are available at http://www.ftsnet.com.

A copy of the trading screen is provided in Figure 3-2. The key features of the trading interface are apparent in this illustration, including the facility to enter bids, asks, prices and quantity. There are also sections to disclose other important information about the game, such as the current bid and ask prices and the current position of the participant in each of the two stocks, ABC and CRA. The two securities may pay dividends at the end of Period 1 and Period 2. The central white rectangle contains the participant's information about the dividends that the shares will pay. The time left (upper left corner) is a critical piece of information because it informs the participants when the market is trading and how much time remains (seconds) in the present trading period.

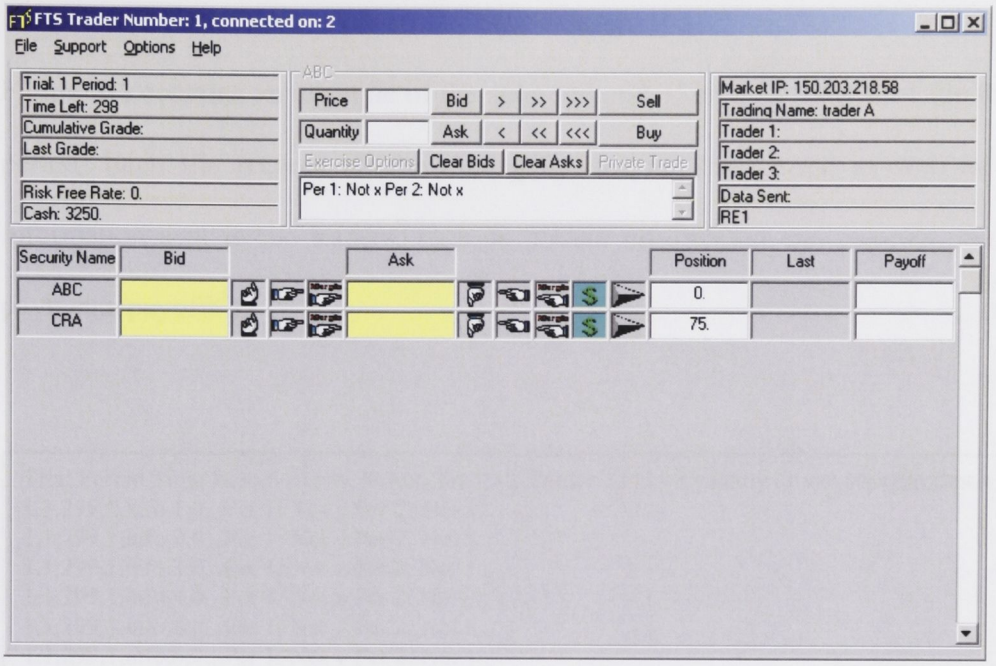

Figure 3-2 - FTS Trader Screen

Figure 3-3 shows an example of the Grade data collected for the first 10 traders in Trial 1 (another data file links 'Trader x' values with participant identifier codes). The first of the numeric values is the cumulative grade cash earned thus far. The second is the trading profit for that trial (profit / 10,000 = grade cash)[4]. These numbers reflect the profitability of the participant's trading.

```
"Trader 1","Trial 1","11.87873","118787.3"
"Trader 2","Trial 1","10.7666","107666."
"Trader 3","Trial 1","0.36375","3637.5"
"Trader 4","Trial 1","-1.9355","-19355."
"Trader 5","Trial 1","2.7944","27944."
"Trader 6","Trial 1","11.322","113220."
"Trader 7","Trial 1","-2.062","-20620."
"Trader 8","Trial 1","10.3773","103773."
"Trader 9","Trial 1","20.68","206800."
"Trader 10","Trial 1","-9.70215","-97021.5"
```

Figure 3-3 - Example of FTS Grade Data Output

[4] This scaling formula is part of the FTS default settings.

Figure 3-4 contains an example of the start and end of an FTS trade data file for one period. Each file records all the trading actions for that period as well as other information sent to the traders, such as private information and payouts (dividend payments/payoffs[5]).

```
Trial,Period,Time Rem,Security,Action,Trader 1,Trader 2,Price,Quantity,Quote,BestBid,BestAsk
1,1,299,1,info,1,0,,,Per 1: Not y Per 2: Not x,,
1,1,299,1,info,2,0,,,Per 1: Not y Per 2: Not y,,
1,1,299,1,info,3,0,,,Per 1: Not z Per 2: Not x,,
1,1,299,1,info,4,0,,,Per 1: Not z Per 2: Not y,,
1,1,299,1,info,5,0,,,Per 1: Not y Per 2: Not x,,
1,1,299,1,info,6,0,,,Per 1: Not y Per 2: Not y,,
1,1,299,1,info,7,0,,,Per 1: Not z Per 2: Not x,,
1,1,299,1,info,8,0,,,Per 1: Not z Per 2: Not y,,
1,1,299,1,info,9,0,,,Per 1: Not y Per 2: Not x,,
1,1,299,1,info,10,0,,,Per 1: Not y Per 2: Not x,,
```

• • •

```
1,1,0,2,Bid,24,0,9.,1000.,9.,13.3,14.4
1,1,0,2,Ask,32,0,16.,100.,16.,13.3,14.4
1,1,0,2,Sell,21,42,13.3,125.,13.3,13.3,14.4
1,1,0,2,Ask,18,0,14.3,1000.,14.3,13.3,14.4
1,1,0,2,Bid,24,0,9.,1000.,9.,13.3,14.3
1,1,0,2,ClearBid,33,0,,,0,13.3,14.3
1,1,0,1,Ask,8,0,11.,10000.,11.,10.9,11.
1,1,0,1,Buy,19,8,11.,100.,11.,10.9,11.
1,1,-4,0,Interest,0,0,,,0,,
1,1,-4,1,Payout,0,0,,,0,10.9,11.
1,1,-4,2,Payout,0,0,24.,,0,13.3,14.3
```

Figure 3-4 - Example of FTS Trade Data Output

3.3.2. Psychometric Testing

A Java-based testing suite called e-bilities® (http://www.ebilities.com), developed by the Lewis Cadman Group, was used to test cognitive abilities. The customised e-bilities® test suite collects demographic information (i.e., name, occupation,

[5] The FTS software and its documentation often use the terms 'payoff', 'payment' and 'payout' interchangeably when referring to the end of period earnings from each security. The terms 'share' and 'stock' are also used interchangeably with the term 'security'.

education, English ability, age, gender and ethnicity) and uses cognitive measures (i.e., Series, Vocabulary, Word Analogies and Quantitative Knowledge). The instrument is based on the well-accepted Cattell-Horn-Carroll model (Carroll, 1993) and is used in the employment, education and health sectors.

This brief summary of the testing tool can be found on the developers' website (e-bilities® test area – About e-bilities®, 2007)[6]:

> e-bilities is a secure web-based cognitive ability testing system which is used for a wide range of assessment purposes, in the areas of work, health, education and research. The highly-credentialed tests are based on contemporary psychological theory, and have been undertaken by thousands of culturally-diverse test-takers from a wide cross section of educational and occupational backgrounds.
>
> … ...
>
> The tests are designed to test mental abilities, without the use of any paper, writing materials, calculators, etc, to help work out the answers. All of the tests include instructions and practice examples.

While the tests within the suite are drawn from standard psychometric test tools, due to a non-disclosure agreement, a detailed explanation of each test is not permissible within this thesis. The following quote provides specific details of this agreement:

> You agree to keep confidential and secret, and not to disclose to any third party, the tests underlying or administered by the Application, including but not limited to the methodology of the tests or the way in which they are applied.
>
> … ...
>
> You agree not to, attempt to, or allow any third party to or to attempt to, reduce or copy the tests administered by the Application into any other form, media or format, including but not limited to paper, and to administer the tests using that form, media or format.

[6] Further information regarding e-bilities® can be found on http://www.ebilitiestest.com/. Please refer to the website for all correspondence concerning the use of e-bilities® for research purposes.

Table 3-12 provides a brief overview of the four tests selected to be part of the test bank.

Abilities Category	**Instrument Name**	**Description** (adapted from e-bilities® Test Info pages)
Fluid	Series	The test-taker has to type in a number that continues a given series of numbers.
Crystallised	Vocabulary	A measure of word-based problem solving and requires the test-taker to choose a synonym for a given word amongst four alternatives.
	Word Analogies	The test-taker has to determine the connection between two words and then find a word that has the same relationship to a third word.
Quantitative Knowledge	Financial Reasoning	The test consists of word-based problems dealing with financial issues, including taxation and interest rate calculations.

Table 3-12 - e-bilities® Test Measures

During testing, participants are not permitted to use pen and paper or any other aids. The experiments used adequate supervision to ensure compliance with this rule. When a question requires the use of an aid (e.g., calculator), the e-bilities® tool provides a web-based version. e-bilities® is not designed to be a repeatable test, and consideration must be made for any data derived after multiple exposures. The participants were filtered prior to taking the test to ensure they had not previously undertaken such testing.

3.3.3. Control Measures

3.3.3.1.Demographic Measures

Certain participant characteristics could affect trading behaviour and performance. Age is linked to life experiences and cognitive ageing. As participants age, their pool

of decision choices and cognitive abilities increase (to a point). Gender can predispose a participant to certain behaviours. It is believed that males can be overconfident and rash while females spend more time thinking before acting (Barber and Odean, 2001). A low level of English literacy would impair a participant's ability to comprehend the instructional materials and understand the test requirements. Participants with sufficient prior trading experience would have the advantage of previous exposure to the task and possibly a better understanding of how to outperform those less experienced.

The demographic questions are relatively simple and have been used in other studies (Foster et al., 2004; 2006). Table 3-13 lists the demographic variables and provides a short description of each one.

Short name	Variable	Operational measure
AGE	Age	Age of the participant [value in years]
GENDER	Gender	Gender of the participant [MALE|FEMALE]
ENGLISH	Was English the participant's first language?	Measure of whether English was the primary language understood [YES|NO].
TRADEBEF	Has the participant traded shares before?	Dichotomous measure of whether a participant has prior share trading experience other than FTS [YES|NO].

Table 3-13 - Demographic Measures from Questionnaire

3.3.3.2.Confidence Measures

Measures of confidence were included because Barber and Odean (2000, 2001) attributed decreased financial performance to possible overconfidence in the traders. The way confidence is measured varies among disciplines. The contents of the

instrument ideally need to be task specific yet flexible in application. A group of simple questions using a five-point Likert scale was constructed. Dhaliwal (1993) and Lamberti and Wallace (1990) have used similar confidence instruments.

At pre-planned intervals (before the first trading session, middle and after the last trading session), the participants were asked to self-report their confidence in performing particular activities. A sample question is presented in Figure 3-5. Full versions of the confidence instruments can be found in Appendices B and C for Experiments 1 and 2 respectively.

5. Confidence in trading with the FTS trading system game

Listed below are activities that could be completed during financial trading with the FTS system. Please indicate how confident you think you would be in performing each activity by circling one number.

If you are not sure of what you will do or what the question refers to, please circle the "0".

a) Pricing a share

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

Figure 3-5 - Sample Question from Confidence Measure

3.3.3.3.Understanding Measures

A trader's ability to perform well (beyond luck) requires them to understand market mechanics. How much participants understand the actions they perform reflects their ability to make consistent purposeful actions. By controlling for the level of understanding a decision-maker has, the effects of cognitive ability and decision-making speed become clearer.

The experiment participants were required to understand four main activities:

a) Comprehension of private information (Figure 3-6 and Figure 3-8)

Most of the time, participants will receive partial information in the form 'Per 1: Not X, Per 2: Not Y' or 'Per 1: Z, Per 2: Not Y'. Being able to interpret such information in its different forms is the vital first step that leads to valid dividend/value calculations.

b) Determining possible dividends in each period (Figure 3-6 and Figure 3-8)

Different information combinations lead to different possible dividend payments at the end of each period. If participants cannot correctly determine those possibilities, they are unable to accurately determine a stock's value.

c) Determining possible values in each period (Figure 3-6 and Figure 3-7)

Once participants have determined possible dividends to be paid, they need to understand which payments apply to which period and the significance of why Period 1 values must consider dividend payments for both periods.

d) Determining the result of a market action (Figure 3-9)

The participants require the ability to recognise the expected results of a particular course of action. A failure to understand this would result in an inability to take meaningful bid, ask, buy and sell trading actions with the FTS.

For stock ABC, if it is state "x" in the first period and state "z" in the second period:

a) What is the dividend paid in period 1? _____

b) What is the dividend paid in period 2? _____

c) What is the value of the share in the first period? _____

d) What is the value of the share in the second period? _____

Figure 3-6 – Sample Dividend Payment/Value Understanding Question

What is the maximum value that ABC can take in period 2? _____

What is the minimum value that CRA can take in period 1? _____

Figure 3-7 – Sample Maximum/Minimum Value Understanding Question

If you know "not z in period 1" for stock ABC what are the possible dividends that could be paid in period 1?

_____

If you know "not y in period 1" and "not x in period 2" for stock CRA what are the possible dividends that could be paid in period 2?

_____

Figure 3-8 - Possible Dividends Understanding Question Example

If the current bid and ask prices / depths are $20 / 200 and $24 / 300, respectively and you place an ask at a price / depth of $25 / 250 will your new ask be used if the next action in the market is a buy order for 100 shares?

_____

Figure 3-9 - Market Actions Understanding Question Example

For each experiment, full versions of the understanding instruments can be found in Appendices B and C for Experiments 1 and 2 respectively.

3.4. Outline of Experimental Procedures

The experimental procedures, which are described below, had three components:

a) FTS training

b) e-bilities® testing

c) FTS trading

3.4.1. FTS Training Session

The FTS training was a scripted 45-minute session for every potential experiment participant (i.e. student studying the first year financial markets course). During this session, the student would sit through a 20-minute slide presentation explaining market mechanics and how to value the shares. At the end of this presentation, they were given the opportunity to practise their skills using FTS in a market structure identical to the experiment proper (though with random market conditions). The trading data from these sessions were not kept and form no part of future calculations within this study.

3.4.2. e-bilities® Testing Session

The e-bilities® test suite can be mentally stressful so was completed either in a separate session or immediately prior to an FTS trading session (with a 10-minute rest period in between). Test-takers were assigned to computers individually and asked to complete a consent form because the e-bilities® data was to be used later. Those who declined to participate were asked to leave while the accepters proceeded to complete the test (which typically takes 30 to 40 minutes). Once finished, they were to sit quietly while browsing the web or reading email. After 50 minutes, those who had not yet finished were asked to terminate the test prematurely. (Test progress up to that point was still valid.)

3.4.3. FTS Trading Session

After successfully completing the training session, the potential experiment participants were asked at a later date to participate in the actual FTS trading session, when research data would be recorded for the purposes of this study. Applicants had

to enrol in this trading session (those who had not completed training were not enrolled). Once the participant limit was reached, enrolments were closed.

At a previously announced date and time, the participants were instructed to arrive at the prearranged location, where they were then randomly assigned to a computer in one of two rooms. As they were seated, each participant was instructed to read and complete the consent form (if not previously completed in an e-bilities® session). Those who did not agree with the terms of participation were free to leave while those who accepted the experimental conditions were instructed to read the materials and complete the first (initial) questionnaire regarding their levels of confidence and understanding (where applicable). After approximately 10 minutes, final preparations were made to allow the first trading trial to commence.

Each market trial lasted 10 minutes and consisted of two five-minute periods. At the beginning of each trial, the participants were allocated cash and securities. They were also given incomplete information on the dividends that were to be paid at the end of each of the two trading periods. Once trading began, the participants flagged their wish to buy or sell securities by entering a bid or ask price, or they could choose to accept existing ask or bid prices. At the end of the first period, the securities paid a dividend depending on the market conditions. There was a short 20- to 30-second pause before the second period started.

At the end of the first trial, the participants were asked to record their Grade Cash value on a supplied payment record sheet. The reason for this is that a nominal fee was paid to each participant consisting of a fixed component and a variable

component based on financial performance. At the end of the trial, each participant's performance was compared with a randomly drawn benchmark value (between 0.000 and 0.999) that was determined by drawing three cards from a shuffled pack of 10 (numbered 0-9), with cards placed back in the pack after each draw. Compensation was paid where performance exceeded the benchmark. Thus, the participants were encouraged to maximise their trading profit in each trial (Plott, 1986). This process of successive trials continued until the end of the session. Further questionnaires were administered at set periods (the mid and end points).

3.5. Ethical Considerations

This research was completed under the Australian National University's 'Responsible Practice of Research' policy[7], which sets out standards for research integrity. All requirements were met. The following clauses warranted further explanation due to their direct influence on the experimental procedure:

> 4.1. Data management should comply with relevant privacy protocols. As the University is constituted under federal legislation it must conform to the Commonwealth Privacy Act 1988. In particular, researchers need to comply with the 11 Information Privacy Principles of the Act. Also relevant is the University's policy Privacy: Statement on the Collection, Use and Control of Personal Information (834/1994). Researchers must not use confidential information for their own personal advantage or that of a third party. Confidentiality may also be necessary for a limited period in the case of contracted research or of non-contractual research, which is under consideration for patent protection.

Clause 4.1 required that any data collected from participants be stored securely and in such a way that participants were not individually identifiable within the data files or within publications produced from that data. To ensure this, participants were

[7] http://info.anu.edu.au/policies/Policies/Research/Other/Responsible_Research_Practice.asp [accessed 9 June, 2006]

assigned unique identifier codes that linked experiment consent forms, e-bilities®, FTS and questionnaire data. Any other documentation linking names to those identifier codes was kept in a physically secure location. Participants were informed of these procedures before participating to alleviate any concerns they may have about being identified by their peers or other parties.

> 4.10. Researchers must be responsible for ensuring appropriate security for any confidential material, including that held in computing systems. Where computing systems are accessible through networks, particular attention to security of confidential data is required. Security and confidentiality must be assured in a way that copes with multiple researchers and the departure of individual researchers.

Clause 4.10 meant that the participants had to be informed that the telecommunication networks were an insecure medium. The e-bilities® test used a HTTPS connection to the test suite server that encrypted all personally identifying information transferred. The data security of the FTS software was unknown, so unique identifier codes were issued to each participant to ensure a high level of anonymity for both data transfer and trading behaviour.

> 5.4. Research must comply with legislation such as the Commonwealth Gene Technology Act 2000 and related Acts, the ACT Animal Welfare Act 1992, the Commonwealth Privacy Act 1988 and established guidelines such as the NHMRC National Statement on Ethical Conduct in Research Involving Humans (1999) and where relevant the Australian Institute of Aboriginal and Torres Strait Islander Research's Guidelines for Ethical Research in Indigenous Studies (2000). It is the obligation of the researcher to comply with such legislation or guidelines and of the Head of the Department or research unit to inform researchers of their obligations with respect to these requirements.

Given that the experiment used human participants, it needed to meet additional guidelines set out by the ANU Human Research Ethics Committee. One condition of

ethics approval was that all participants sign a consent form before commencing the experiment which stated that they had the option of leaving the experiment at any time.

Participants received monetary payments of a set amount for experiment attendance and a variable amount based on financial performance. The participation consent form explained the rules for which payments were calculated. If the participant left the experiment before completion, they received payment for attendance and trading performance up to the point in time which they left. Foster et al. (2004) found such a payment mechanism to be effective for encouraging profit-seeking behaviour and maintaining a positive attitude in participants.

3.6. Conclusion

This chapter has presented the experimental conditions common to Experiment 1 and Experiment 2. Specific features that are unique to each experiment are discussed in Chapter 4 and Chapter 5 respectively.

Chapter Four

Experiment 1: Electronic Market Simulation

'If the human mind was simple enough to understand,
we'd be too simple to understand it.' – Emerson Pugh

4.1. Introduction

Computer-based simulations of electronic markets have been shown to be an effective experimental vehicle. However, research into the use of decision aids and the effect of cognitive abilities on trading performance within double auction share markets is sparse. Because this study involved a new area of research, an initial experiment was conducted to determine the effect of novice trader abilities and characteristics on their performance in a DA share market (thus establishing a baseline). The effect of a decision aid on investor behaviour is examined in a later experiment, the design of which involved a partial replication of the baseline experiment.

4.2. Method

4.2.1. Participants

The participants were 43 volunteers from a class of approximately 400 students studying a first year university finance course. The sample consisted of 17 females and 26 males with a median age of 20. Due to the nature of the electronic market experiment and experiment setting constraints, a limited number of participants could be involved in a single experiment. As this results in a relatively small sample size, a very careful analysis of the data, including cleaning and normality checks, was performed. By doing this, the effect of strong outliers (novice traders with an extreme level of performance) could be controlled.

Six participants indicated that they had prior share trading experience, though that experience was not sufficient enough to influence performance. All the participants had previously used the FTS under experimental conditions. Although approximately 72 per cent of the participants indicated that English was not their first language, the level of English language proficiency was deemed sufficient because undergraduate student admission requirements require adequate English language competency (ANU, 2005).

Based on anecdotal feedback and personal observations within the experimental environment, participants were able to comprehend the instructional material, and their understanding was sufficient to participate actively in trading. The participants were also asked to complete a questionnaire testing their understanding of how to calculate dividend payments, value shares and game mechanics.

4.2.2. Procedure

The experiment had two parts—an initial training session and the experiment proper. In the training session, each participant first completed an e-bilities® test to measure his or her cognitive abilities. This took approximately 45 minutes. The participants were then shown how to use the FTS, which would be used in the second half of the experiment. Following this demonstration, the subjects participated in four trials (10 minutes per trial) of the system under conditions similar to what they would experience in the experiment. Each trial consisted of two five-minute periods of trading. The FTS part of the training session took approximately one hour.

The experimental session was conducted six weeks later and took approximately two hours. Within that two-hour period, six trials were conducted, each with two five-minute trading periods. Before the first trial, the participants were asked to answer a questionnaire in order to record their initial confidence with trading activities. The first trial then commenced. There was a brief 15-second break between trading periods followed by a two- to three-minute break after each trial. During the trial break, a random hurdle number was drawn and financial performance based payments were calculated based on a comparison of the grade cash performance measure and the random number. If the grade cash exceeded the random number, the participant received a payment. Otherwise no payment was received. This payment process was designed to encourage risk neutral profit-seeking behaviour (O'Brien and Srivastava, 1991). The trading-payment process was repeated each trading period until the end of the sixth (and last) trial. Questionnaires 2 and 3 were completed at the end of the third and sixth trials respectively.

4.2.3. Materials

Appendix B shows an example of the printed materials handed out to each participant as they moved to their allocated computer within the lab. The bound material, in the order provided, comprised:

- an experiment participation consent form
- an experimental procedure sheet containing
    - an outline of the planned sequence of events
    - their e-bilities® authentication details
    - their trader ID number for FTS
    - a payment record table to track their financial progress across trials

- an FTS explanation sheet which explained
    - the purpose of FTS and its role in the experiment
    - the FTS interface
    - how to interpret the private information
- Three questionnaires
    - Questionnaire 1
        - Demographics
        - Confidence before FTS trading
        - Task reactions (unused in this study)
    - Questionnaire 2
        - Confidence mid-way through FTS trading
        - Understanding of trading principles
    - Questionnaire 3
        - Confidence after FTS trading finished
        - Task reactions (unused in this study)

The FTS configuration settings for the RE1 trading case are presented in Table 4-1 to Table 4-5.

Number of Securities	2
Maximum Number of Trials	8
Number of Periods per Trial	2
Period Length (seconds)	300
Maximum Number of Traders	60
Number of Trader Types	2
Market Depth	10
Depth Displayed	5
Borrowing Allowed	Yes
Last Row with Exogenous Prices	
Number of Information Types	9
Last Row with Information	36
Recalculate	No

Table 4-1 - Experiment 1 Market Configuration

Name	ABC	CRA
Security Type	Stock	Stock
Price Quotes	Endogenous	Endogenous
Start Life	1	1
End Life	2	2
Short selling	Yes	Yes
Quote to Price Formula	Quote	Quote
Information	Yes	Yes

Table 4-2 - Experiment 1 Security Configuration

Trader Data	Type 1	Type 2
Cash	3250	750
Endow 1	0	100
Endow 2	75	75
Rights 1	0	0
Rights 2	0	0
Lower Bound	-1E+08	-100000000
Lower Bound Payoff	-10000	-10000
Upper Bound	1E+08	100000000
Upper Bound Payoff	10000	10000
Constant	0	0
Linear Coefficient	0.0001	0.0001
Quadratic Coefficient	0	0
Log Coefficient	0	0
CARA Coefficient	0	0
CARA Exponent	0	0
HARA Coefficient	0	0
HARA Exponent	0	0

Table 4-3 - Experiment 1 Starting Position Configuration

Payoff and Settlement Data	Stock 1	Stock 2	Interest Rate
Trial 1	0	24	0
Period 2	12	8	0
Trial 2	12	12	0
Period 2	0	8	0
Trial 3	12	0	0
Period 2	24	18	0
Trial 4	12	12	0
Period 2	24	12	0
Trial 5	24	12	0
Period 2	24	18	0
Trial 6	24	12	0
Period 2	12	8	0
Trial 7	24	24	0
Period 2	24	12	0
Trial 8	24	12	0
Period 2	12	8	0

Table 4-4 - Experiment 1 Payoff Configuration

Work area			
S1 draws	S2 Draws	S1 Payoff	S2 Payoff
1	4	0	24
3	1	12	8
2	3	12	12
1	2	0	8
2	1	12	0
3	4	24	18
2	2	12	12
3	3	24	12
3	3	24	12
3	4	24	18
3	3	24	12
2	2	12	8
3	4	24	24
3	3	24	12
3	2	24	12
2	2	12	8

Table 4-5 - Experiment 1 Private Information and Payoff Configuration

For a more detailed explanation of the web-based e-bilities® test suite, FTS and questionnaires administered to the participants, refer to Chapter 3.

4.2.4. Design

The purpose of this experiment was to derive a better understanding of what happens inside an experimental financial market when the participants are novice share traders who have no decision aids.

The primary dependent variable was overall financial performance (FINP_TOT). It was calculated from the profit (loss) earnings (also known as grade cash) of each participant's trades over the length of the entire experiment (six trials).

Short name	Variable	Operational measure
FINP_TOT	Overall financial performance from trading in 6 trials.	Sum of the participant financial trading performance figures for all 6 trials [±N].

Table 4-6 - Financial Performance Measures

The accuracy components (percentage of test items answered correctly) of the four e-bilities® measures (as seen in Table 3-12) were sorted into their parent categories (Fluid, Crystallised and Quantitative Knowledge). From those measures, an average variable was created for each of the three cognitive ability types. These three new variables, FLUID, CRYST and QK, were used as the cognitive independent variables in the analysis described below.

Short name	Variable	Operational measure
FLUID	Fluid ability	Average accuracy of fluid ability cognitive measures generated from the e-bilities® testing suite [0-100%].
CRYST	Crystallised ability	Average accuracy of crystallised ability cognitive measures generated from the e-bilities® testing suite [0-100%].
QK	Quantitative knowledge	Average accuracy of quantitative knowledge cognitive measures generated from the e-bilities® testing suite [0-100%].

Table 4-7 - Cognitive Ability Measures

The fourth independent variable is the number of trading actions, which was measured for all six trials (NUM_ACTS _TOT).

Short name	Variable	Operational measure
NUM_ACTS _TOT	Total number of trading actions in 6 trials.	Sum of all ask, bid, buy and sell actions by participants for all 6 trials [N].

Table 4-8 - Trading Actions Measures

The control covariates were gender (GENDER), prior trading experience (TRADEBEF) and whether English was the participant's first language (ENGLISH).

Short name	Variable	Operational measure
GENDER	Gender	Gender of the participant [MALE|FEMALE]
ENGLISH	Was English the participant's first language?	Measure of whether English was the primary language understood [YES|NO].
TRADEBEF	Has the participant traded shares before?	Dichotomous measure of whether a participant has prior share trading experience other than FTS [YES|NO].

Table 4-9 - Demographic Measures

Participants completed three questionnaires, with confidence states CONF_BEF, CONF_MID and CONF_END being measured before Trial 1, after Trial 3 and after Trial 6 respectively. These three values were also averaged to create CONF_OVR.

Short name	Variable	Operational measure
CONF_BEF	Confidence before trading started	Average self-reported value from the 5 trading confidence questions before Trial 1 commenced [0-5].
CONF_MID	Confidence at mid point	Average self-reported value from the 5 trading confidence questions after Trial 3 but before Trial 4 commenced [0-5].
CONF_END	Confidence at end of trading	Average self-reported value from the 5 trading confidence questions after Trial 6 [0-5].
CONF_OVR	Average confidence overall	Average overall confidence level calculated from CONF_BEF, CONF_MID and CONF_END [0-5].

Table 4-10 - Confidence Measures

Midway through the trading (after Trial 3 and before Trail 4 commenced), participants completed Questionnaire 2 (Appendix B), which measured their level of understanding of certain activities. UND_DIV is the sum of the first four questions (Q1a-Q1d) of Section 2, which tests their understanding of calculating dividend payoffs. UND_PRI is the sum of the next 14 (Q2-Q15) questions, which tested the participants' ability to understand price calculations. These measures were included for control purposes to ensure that the participants' level of understanding of the game was not responsible for any differences in performance.

Short name	Variable	Operational measure
UND_DIV	Understanding of calculating dividend values	Number of correct responses to dividend calculation questions [0-4]
UND_VAL	Understanding of calculating share values	Number of correct responses to pricing calculation questions [0-10]
UND_PRI	Understanding of calculating prices	Number of correct responses to pricing calculation questions [0-4]

Table 4-11 - Understanding Measures

The variables used in the regression analysis are summarised in Table 4-12.

Variable Type	Variable Name	Description
Dependent	FINP_TOT	Financial Performance
Independent	FLUID	Fluid ability
	CRYST	Crystallised ability
	QK	Quantitative knowledge
	NUM_ACTS_TOT	Number of trading actions
Control	GENDER ENGLISH TRADEBEF	Demographics
	CONF_BEF CONF_MID CONF_OVR	Confidence
	UND_DIV	Understanding of dividend calculations
	UND_VAL	Understanding of value calculations
	UND_PRI	Understanding of pricing calculations

Table 4-12 - Experiment 1 Variables

4.3. Preliminary Data Analysis

4.3.1. Data Screening

The initial treatment of the raw data reflected the form in which it was collected and recorded. Data from the paper questionnaires were manually entered into an Excel

spreadsheet and the results were merged with imported FTS and e-bilities® data. After initial spot checks to make sure the merge was consistent, the consolidated data was imported into SPSS v11 (http://www.spss.com) for comprehensive screening, as described in Tabachnick and Fidell (2001).

The first step in the data screening process was to check whether the minimum and maximum values for each variable fell within a plausible range. Table 4.13 lists the descriptive statistics for each variable. The values of every variable fell within an acceptable range. There were no inappropriately negative (i.e., trade actions must be >= 0) or unrealistic values (i.e., cognitive values must be >= 0 but <= 1).

	N	Minimum	Maximum	Mean	Std. Deviation
FINP_TOT	43	-1217.52	3831.28	3.2014	687.95119
FLUID	43	.27	1.00	.7781	.15329
CRYST	43	.27	.85	.5569	.15641
QK	43	.08	.92	.5619	.21833
NUM_ACTS _TOT	43	58	2556	646.19	595.703
CONF_BEF	43	1.00	4.70	3.0907	.77208
CONF_MID	43	1.00	4.80	3.1093	.99542
CONF_END	43	1.80	5.00	3.4274	.87453
CONF_OVR	43	1.33	4.53	3.2091	.75675
UND_DIV	43	.00	1.00	.5523	.32070
UND_VAL	43	.00	.70	.2442	.22710
UND_PRI	43	.00	1.00	.4826	.31051
Valid N (listwise)	43				

Table 4-13 - Experiment 1 Descriptive Statistics

The data was then screened to ensure the means and standard deviations listed in the table were also plausible. Financial performance means should be slightly greater than 0 due to the small starting position. The reason for a mean of approximately 0 is that any profit one participant makes must result from a corresponding loss by one or more other participants.

The cognitive ability means were expected to be greater than 0.5 (the midpoint of the 0.0-1.0 scale). Because the sample consisted of students who had had to meet academic entry requirements for admission to the university, the means for cognitive ability were higher than average.

The number of trade actions is entirely dependent upon the choices a participant makes. It may range from a few trades per period to rapid mouse clicking every second. Visual observations of the participants showed that some novice traders traded only a few times each period while others traded very frequently.

Confidence was measured using a five-point Likert scale, with a rating of '1' representing no confidence and '5' representing total confidence. Due to the participants having undergone FTS training, it was expected that their initial confidence would be moderate (approximately 3).

Understanding was measured using a series of questions about different aspects of common activities—valuation, pricing and mechanics. The more questions a participant correctly answered, the higher this value.

Outliers were evident. One participant excelled at trading for financial gain and therefore had a high FINP_TOT value of 3831.28, which was more than five standard deviations above the mean. Due to the nature of a closed trading environment with relatively small starting positions in terms of cash and securities, any financial gain from a trading action is mirrored by a loss for one or more other novice traders. Rather than removing outliers, a ranked normalised FINP_TOT value was created

(T_FINP_TOT) using Blom's formula to mirror the otherwise normal distribution of FINP_TOT. This substituted normal values while retaining the original order of values.

Some participants also exhibited unusually high levels of trading. The trading behaviour of participants was not restricted and they were left to develop strategies of their own choosing. The FTS software supported this behavioural freedom by allowing traders to manually enter each price and quantity for a trading action or, alternatively, use a hand signal button to quickly buy, sell, increase or decrease the prices. This flexibility allowed the novice traders to quickly perform an action, ideally one benefiting them financially, if they were willing to accept the inherent danger of clicking too quickly and making a mistake. Rather than exclude these participants from the sample, the 'number of actions' variables for all participants were transformed. A square root transformation also addressed the left skewness of these variables (as discussed in Step 4).

One participant had a fluid cognitive ability score of 0.27, well below the mean of 0.7781. This person's other cognitive ability scores were checked. The low value on fluid ability was found to be consistent with the subject's scores on the crystallised and quantitative knowledge indicators. Therefore, it was retained in the data.

No other outliers were found in the sample data. Given that no participants were excluded, the data from all 43 traders was kept for the next screening step.

The descriptive statistics in Table 4.13 show the presence of missing data (i.e., where *n* does not equal 43). For the composite variables CRYST, CONF_END, QK and FLUID, the missing cases are due to missing data in the instruments they are derived from and were addressed as recommended by Tabachnick and Fidell (2001).

One participant suffered from a computer malfunction and was unable to record a complete set of e-bilities® values. Two other participants were unable to complete the e-bilities® test within the allotted time period and had to forgo the completion of the Quantitative Knowledge e-bilities® test case. Due to the fairly small sample used in the experimental market, mean values were substituted for this data.

A fourth participant had to leave the experiment after the fourth trading trial for personal reasons. Sample mean values were substituted for missing confidence values data. Missing trade data was resolved by treating the participant as present but not active within the market for the last two trials. This resulted in zero trading actions and relatively small financial performance values (due to the small starting position).

A fifth participant did not fully complete the third confidence questionnaire administered at the end of trading. The mean for those two questions was substituted in place of the missing values. These adjustments ensured that all 43 novice traders were kept within the study.

	N	Skewness		Kurtosis	
	Statistic	Statistic	Std. Error	Statistic	Std. Error
FINP_TOT	43	3.945	.361	23.767	.709
FLUID	43	-1.072	.361	1.472	.709
CRYST	43	-.179	.361	-1.059	.709
QK	43	-.393	.361	-.437	.709
NUM_ACTS _TOT	43	1.690	.361	3.075	.709
CONF_BEF	43	-.338	.361	-.129	.709
CONF_MID	43	-.149	.361	-.852	.709
CONF_END	43	-.015	.361	-.740	.709
CONF_OVR	43	-.140	.361	-.605	.709
UND_DIV	43	-.341	.361	-.865	.709
UND_VAL	43	.495	.361	-1.154	.709
UND_PRI	43	.060	.361	-.960	.709
Valid N (listwise)	43				

Table 4-14 - Experiment 1 Descriptive Statistics for Normality – Before Transformations

From the data shown in Table 4-14, the following variables were identified as skewed (more than two standard errors from zero): NUM_ACTS_TOT, FINP_TOT and FLUID. When checking for kurtosis, the following variables were found to be leptokurtic (more than two standard errors from zero): FINP_TOT, NUM_ACTS_TOT and FLUID.

The normality of the trading action variable was addressed by using a square root transformation to create T_NUM_ACTS_TOT. The normality of the financial performance variable was addressed by using a rank transformation to create T_FINP_TOT. The non-normality of FLUID was resolved by using a reflect and square root transformation[8], which generated T_FLUID.

[8] The square root of a negative number cannot easily be expressed. The reflect process is performed by taking the maximum value and adding 1 (so it is the largest unique value) to form a constant. A new variable is then created by subtracting each original value from the constant. This 'reflects' the shape of a negatively skewed distribution to a positive one. It also means the direction of the variable changes, which affects the interpretation.

	N	Skewness		Kurtosis	
	Statistic	Statistic	Std. Error	Statistic	Std. Error
T_FINP_TOT	43	.000	.361	-.272	.709
T_FLUID	43	.092	.361	.075	.709
CRYST	43	-.179	.361	-1.059	.709
QK	43	-.393	.361	-.437	.709
T_ NUM_ACTS _TOT	43	-.142	.361	-.640	.709
CONF_BEF	43	-.338	.361	-.129	.709
CONF_MID	43	-.149	.361	-.852	.709
CONF_END	43	-.015	.361	-.740	.709
CONF_OVR	43	-.140	.361	-.605	.709
UND_DIV	43	-.341	.361	-.865	.709
UND_VAL	43	.495	.361	-1.154	.709
UND_PRI	43	.060	.361	-.960	.709
Valid N (listwise)	43				

Table 4-15 – Experiment 1 Descriptive Statistics for Normality – After Transformations

4.3.2. Reliability of Instruments

Before performing primary analysis, an evaluation of the scales to measure cognitive abilities and confidence (as seen in Appendix B) was undertaken. The cognitive abilities measure (i.e., e-bilities®) is based on measures by Anstey (1999), which were validated before use in this experiment. For further information, the technical manual is available upon request.

The confidence scales were necessary for primary analysis. They were designed in previous experiments and had proven themselves in practice[9]. A principal components analysis with no rotation was performed on the 10 items related to the participant's confidence in performing certain actions. Due to the data screening and missing item analysis, there was a complete set of 43 responses. In all cases, the components loaded onto one component. Cronbach alpha values also indicated the lower bound estimate of internal consistency was .958 for overall confidence, indicating satisfactory internal consistency (Cortina, 1993).

[9] The task reaction scales that can also be found in Appendix B are not used as part of this study

4.4. Control Variables

The control variables were also examined for significance. Confidence in trading ability was not significantly related to performance. This measure was introduced into the analysis as a control variable to guard against the situation where performance was influenced by the degree of confidence in performing trading actions. The lack of significance of this variable indicates that confidence itself was not a differentiating factor in the performance level achieved.

The participants' understanding of how to calculate dividends, share values and payments was also not significantly related to performance. These measures were introduced into the analysis as control variables to guard against a situation where performance was influenced by the participants' degree of understanding. The lack of significance of these variables indicates that knowledge of the information itself was not a differentiating factor in the performance level achieved.

Other demographic variables, including gender, age and prior financial trading experience, were also examined as potential covariates. None of these variables was found to be significantly related to novice trading performance.

4.5. Primary Analysis

A standard linear regression model in SPSS v15 was used to test the experimental hypotheses. The endogenous dependent variable is overall financial performance. There were four exogenous independent variables: fluid cognitive ability, crystallised

cognitive ability, quantitative knowledge and total trading actions. The data was entered into Microsoft Excel 2003 before being imported into SPSS v15 for analysis.

An a priori test was run with G*Power (Faul et al., 2007) to compute the required sample size (Figure 4-1). In order to find a statistically significant relationship in the regression for a large effect (f^2=.35) with four independent variables, a sample size of at least 40 was required to achieve power of at least .80 (p=.05).

F tests - Multiple Regression: Omnibus (R^2 deviation from zero)		
Analysis:	A priori: Compute required sample size	
Input:	Effect size f^2	= 0.35
	α err prob	= 0.05
	Power (1-β err prob)	= .80
	Number of predictors	= 4
Output:	Noncentrality parameter λ	= 14.000000
	Critical F	= 2.641465
	Numerator df	= 4
	Denominator df	= 35
	Total sample size	= 40
	Actual power	= 0.811023

Figure 4-1 - Power analysis - required sample size

Data screening was carried out before the regression analysis. With four independent variables, a sample size of 43 is sufficient for the minimum of 5:1 cases to variables ratio suggested by Tabachnick and Fidell (2001) if the effect is large. Although a minimum sample size of 74 (n > 50 + 8m) is recommended by Green (1991), such a number is not feasible because of problems arising from having many people trading in one FTS market simultaneously. Sensitivity analysis calculated using G*Power found an effect size ($f2$) of 0.31 is required for a sample size of 43 (Figure 4-2).

F tests – Multiple Regression: Omnibus (R^2 deviation from zero)			
Analysis:	Sensitivity: Compute required effect size		
Input:	α err prob	=	0.05
	Power (1–β err prob)	=	.80
	Total sample size	=	43
	Number of predictors	=	4
Output:	Noncentrality parameter λ	=	13.512698
	Critical F	=	2.618988
	Numerator df	=	4
	Denominator df	=	38
	Effect size f^2	=	0.314249

Figure 4-2 - Power analysis - required effect size

The results from evaluating the underlying assumptions led to a transformation of the variables to reduce the number of outliers, reduce skewness and improve the normality, linearity and homoscedasticity of the residuals. These transformations were discussed in the previous section. With the use of a $p < .001$ criterion for Mahalanobis distance, no multivariate outliers among the cases were found. The maximum distance value was 8.219, which is well below the critical value of 18.467 (4 IVs). No cases within the regression had missing data (after manipulation) and no suppressor variables were found ($n = 43$). The resulting scatterplot of the regression standardised residual and the regression standardised predicted value for normalised overall financial performance can be seen in Figure 4-3. The normal P-P plot of the regression standardised residual shown in Figure 4-4 also resembles a reasonably straight line, so normality assumptions appear not to be violated (after transformation).

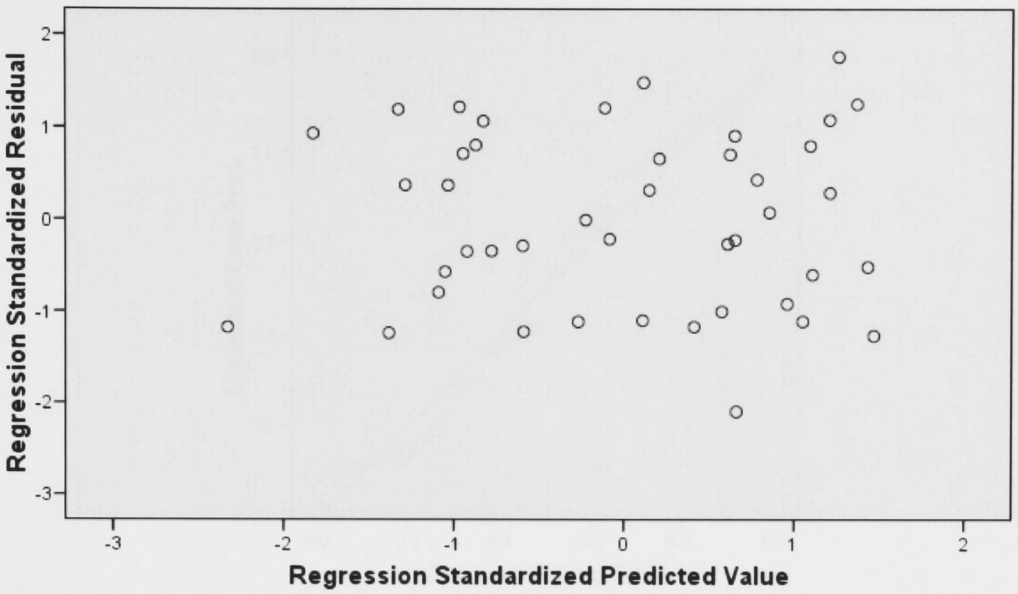

Figure 4-3 - Scatterplot of the Regression Standardised Residual vs Regression Standardised Predicted Value for Normalised Overall Financial Performance

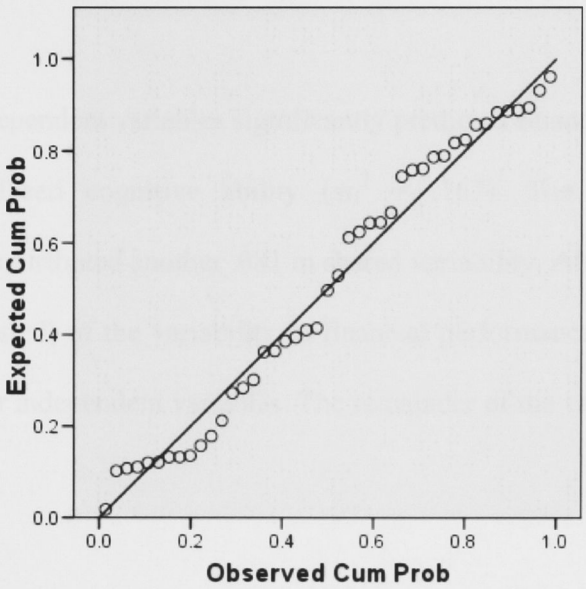

Figure 4-4 - Normal P-P Plot of Regression Standardised Residual

Bivariate correlations were performed to check the existence of multicollinearity among the independent variables. No values were greater than .7. Therefore, all the variables were retained (Tabachnick and Fidell, 2001). In addition, SPSS was used to perform collinearity diagnostics and create tolerance and variance inflation factor (VIF) values. The lowest tolerance value was .706 and the highest VIF value was 1.417. Both of these are well above and below their respective common cut-off points of .10 and 10.

Table 4-17 displays (in the style used by Tabachnick and Fidell, 2001) the correlations among the variables, the unstandardised regression coefficients (B) and intercept, the standardised regression coefficients (β), the semi-partial correlations

(sr_i^2) and R^2, and the adjusted R^2. The regression value R was significantly different from zero, $F(4, 38) = 3.127$, $p < .05$. Further, 95 per cent confidence limits were calculated to test that the regression coefficients differed significantly from zero. The confidence limits for crystallised cognitive abilities were .872 and 4.881.

Only one of the independent variables significantly predicted financial performance as normalised—crystallised cognitive ability ($sr_i^2 = .167$). The four independent variables together contributed another .081 in shared variability. Altogether, almost 25 per cent (17% adjusted) of the variability in financial performance was predicted by scores for these four independent variables. The remainder of the variability

Variable Type	Variable Name	Description
Dependent	T_FINP_TOT	Transformed "Financial Performance"
Independent	T_FLUID	Transformed "Fluid ability"
	CRYST	"Crystallised ability"
	QK	"Quantitative knowledge"
	T_NUM_ACTS_TOT	Transformed "Number of trading actions"

Table 4-16 - Experiment 1 Variable Name Legend for Table 4-17

Variables	T_FINP_TOT (DV)	T _FLUID	CRYST	QK	T_NUM_ACTS_TOT	*B*	*β*	sr^2 (unique)
T_FLUID	-.134					-.840	-.139	
CRYST	.440**	-.162				2.876	.459	.167**
QK	.222^	-.381**	.439**			-.015	-.003	
T_NUM_ACTS_TOT	-.116	-.327*	.169	.121		-.566	-.238	
					Intercept = .281			
Means	.000	.454	.557	.562				
Standard deviations	.979	.162	.156	.218		R^2 = .248[a]		
						Adjusted R^2 = .168		
						R = .598*		

^ p < .10 * p < .05 ** p < .01 *** p < .001

[a]Unique variability = .167; shared variability = .081

Table 4-17 - Standard Multiple Regression of Confidence, Cognitive Abilities, Number of Trading Actions and Understanding on Financial Performance (n = 43)[10]

[10] Refer to Tabachnick and Fidell (2001) for a detailed explanation of this statistical reporting method.

4.6. Discussion

The purpose of Experiment 1 was to get a better understanding of how a double auction share market operates and the influence of decision-maker characteristics on outcomes. The following hypotheses were tested:

H1a: *A higher level of fluid ability will lead to higher performance in financial trading by novice traders.*

H1b: *A higher level of crystallised ability will lead to higher performance in financial trading by novice traders.*

H1c: *A higher level of quantitative ability will lead to higher performance in financial trading by novice traders.*

H2: *Higher decision-making speed will lead to lower performance in financial trading by novice traders.*

Figure 4-5 shows the research model for the hypotheses tested in Experiment 1.

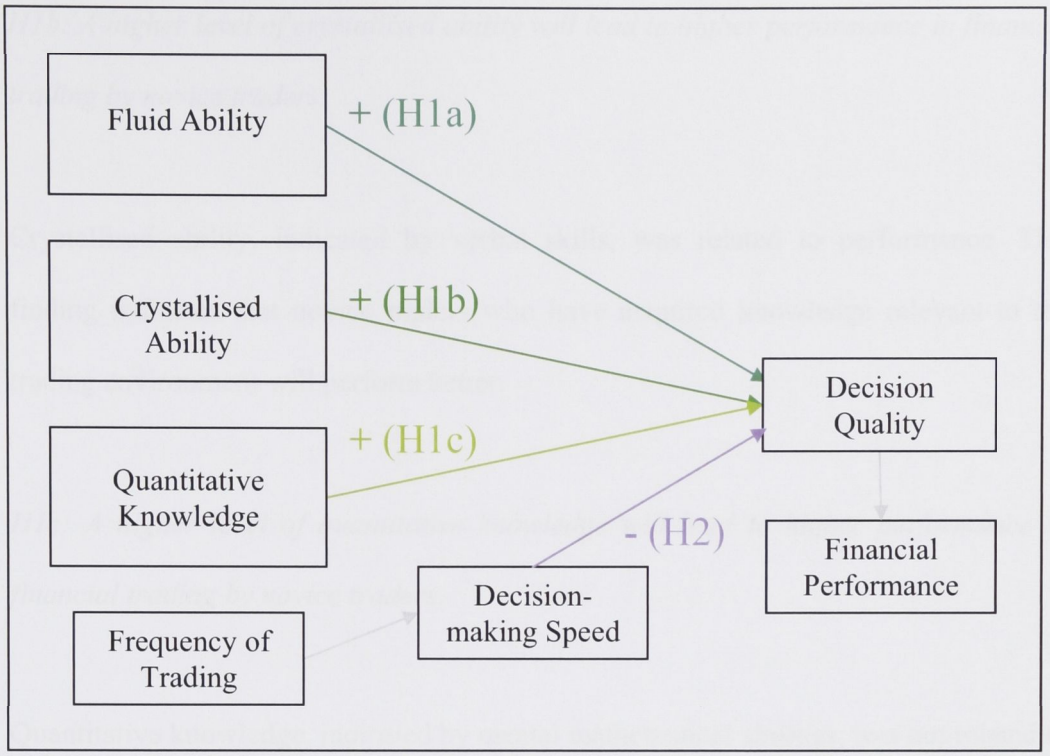

Figure 4-5 – Experiment 1 Research Model

The results show that H1b (crystallised ability) was supported but H1a (fluid ability), H1c (quantitative knowledge) and H2 (number of trading actions) were not. The intellectual abilities of the novice traders were shown, in part, to be related to performance.

H1a: A higher level of fluid ability will lead to higher performance in financial trading by novice traders.

The fluid ability measure, which indicates innate reasoning abilities, was not related to performance. This finding suggests that better working memory and faster problem solving abilities were less important for financial trading.

H1b: A higher level of crystallised ability will lead to higher performance in financial trading by novice traders.

Crystallised ability, indicated by verbal skills, was related to performance. This finding indicates that novice traders who have acquired knowledge relevant to the trading environment will perform better.

H1c: A higher level of quantitative knowledge will lead to higher performance in financial trading by novice traders.

Quantitative knowledge, indicated by mental mathematical abilities, was not related to performance. This finding indicates that novice traders who excel at mental arithmetic will not necessarily perform better.

H2: Higher decision-making speed will lead to lower performance in financial trading by novice traders.

The findings show that the number of trading actions was not significantly related to financial performance. This means that H2 is not supported. However, the transformations to address the breaches of normality may have reduced the effects of the extreme novice traders (i.e., those who traded excessively when compared to the mean). The untransformed financial performance and number of trading action variables were not correlated.

4.7. Conclusion

The purpose of this first experiment was to investigate the relationships between cognitive ability, decision-making speed and financial performance. It was found that crystallised ability influences financial performance, but fluid ability, quantitative knowledge and the number of trading actions undertaken do not. Confidence in trading ability, understanding how to calculate dividend payments, pricing and share values were not significantly related to performance. Other demographic variables, including gender, age, and prior financial trading experience, were examined as potential covariates but were not found to significantly influence trading performance. The results of this initial investigation will now be used as a baseline for examining the results of Experiment 2, which are reported in the next chapter. In Experiment 2, the experimental design is extended by the introduction of a decision aid.

Chapter Five
Experiment 2: Decision Aid

'A great many people think they are thinking when they are merely rearranging their prejudices.' - William James

5.1. Introduction

The study reported in Chapter 4 focused on understanding the electronic market and what factors influence financial performance. A positive relationship between financial performance and crystallised cognitive ability was found. Otherwise, there were no significant relationships between financial performance and any of the potential explanatory variables or control variables.

This chapter describes a second experiment that had the aim of testing the efficacy of a decision aid provided to participants in an electronic market. The experimental method was similar to that used in Experiment 1 except there were two treatment groups: one with a decision aid and one without. Interaction effects between the primary constructs and the aid use were investigated.

5.2. Method

5.2.1. Participants

The participants were 30 volunteers from a class of approximately 400 students in a first year university finance course. This sample consisted of nine females and 21 males. The median age was 19 years. Approximately 47 per cent of the participants indicated that English was not their first language, although they had met the

minimum TESOL English proficiency standard that is a requirement of their university enrolment[11].

5.2.2. Procedure

The experiment had two parts—an initial training session and the experiment proper. In the training session, each participant first completed an e-bilities® test to measure his or her cognitive abilities. This took approximately 45 minutes. The participants were then shown how to use the FTS. They then participated in four trials of the system under conditions similar to those of the experiment proper. Each trial consisted of two five-minute periods of trading. This part of the training session took approximately one hour.

For the main experiment a month later, the participants were allocated randomly to two groups. One group was provided with a decision aid (16 participants) and the other group did not receive an aid (14 participants). This experimental session took two hours and involved six trials, each with two five-minute periods of trading. There was no training immediately prior to this experiment.

5.2.3. Materials

Appendix C contains an example of the printed materials provided to each participant when they were allocated a computer in the laboratory. The bound materials, in the order provided, comprised:

- an experiment participation consent form
- an experiment procedure sheet containing

[11] TESOL (Teachers of English to Speakers of Other Languages) accreditation, or an equivalent, is a requirement of enrolment.

    - an outline of the planned sequence of events
    - e-bilities® authentication details
    - a trader ID number for FTS
    - a guide to reading private information (specific to the treatment group)
    - a payment record table to track financial progress across trials
- a FTS explanation sheet which explained
    - the purpose of FTS and its role in the experiment
    - the FTS interface
- a Dividend Determination Sheet
    - explanation of how to calculate dividend payments
    - explanation of how to value shares
    - sufficient tables for six trading trials using pen and paper calculations
- Questionnaires (treatment group specific)
    - Without Aid
        - Questionnaire 1
            - Confidence before FTS trading
            - Understanding of trading principles
        - Questionnaire 2
            - Understanding of trading principles
    - With Aid
        - Questionnaire 1A
            - Confidence before FTS trading
            - Understanding of trading principles
        - Questionnaire 2A
            - Perceived usefulness of aid

- Perceived trust of aid

- Questionnaire 3A
  - Perceived usefulness of aid
  - Perceived trust of aid
  - Understanding of trading principles

Table 5-1 to Table 5-5 show the FTS configuration settings for the RE1 trading case.

Number of Securities	2
Maximum Number of Trials	8
Number of Periods per Trial	2
Period Length (seconds)	300
Maximum Number of Traders	90
Number of Trader Types	2
Market Depth	10
Depth Displayed	5
Borrowing Allowed	Yes
Last Row with Exogenous Prices	
Number of Information Types	9
Last Row with Information	36
Recalculate	No

Table 5-1 - Experiment 2 Market Configuration

Name	ABC	CRA
Security Type	Stock	Stock
Price Quotes	Endogenous	Endogenous
Start Life	1	1
End Life	2	2
Short selling	Yes	Yes
Quote to Price Formula	Quote	Quote
Information	No	No

Table 5-2 - Experiment 2 Security Configuration

Trader Data	Type 1	Type 2
Cash	3250	750
Endow 1	0	100
Endow 2	75	75
Rights 1	0	0
Rights 2	0	0
Lower Bound	-1E+08	-100000000
Lower Bound Payoff	-10000	-10000
Upper Bound	1E+08	100000000
Upper Bound Payoff	10000	10000
Constant	0	0
Linear Coefficient	0.0001	0.0001
Quadratic Coefficient	0	0
Log Coefficient	0	0
CARA Coefficient	0	0
CARA Exponent	0	0
HARA Coefficient	0	0
HARA Exponent	0	0

Table 5-3 - Experiment 2 Starting Position Configuration

Payoff and Settlement Data	Stock 1	Stock 2	Interest Rate
Trial 1	12	24	0
Period 2	12	8	0
Trial 2	24	12	0
Period 2	24	8	0
Trial 3	12	24	0
Period 2	0	18	0
Trial 4	0	12	0
Period 2	12	18	0
Trial 5	24	24	0
Period 2	12	8	0
Trial 6	0	12	0
Period 2	0	18	0
Trial 7	24	12	0
Period 2	12	8	0
Trial 8	24	0	0
Period 2	12	18	0

Table 5-4 - Experiment 2 Payoff Configuration

Work area			
S1 draws	S2 Draws	S1 Payoff	S2 Payoff
2	4	12	24
2	2	12	8
3	2	24	12
3	2	24	8
2	4	12	24
1	4	0	18
1	2	0	12
3	4	12	18
3	4	24	24
1	2	12	8
1	2	0	12
1	4	0	18
3	2	24	12
2	2	12	8
3	1	24	0
1	4	12	18

Table 5-5 - Experiment 2 Private Information and Payoff Configuration

In the original FTS system, the central white rectangle in the screen would normally contain the participant's private information about the dividend that a share would pay (Figure 5-1). For this experiment, the package was modified so that the private information was displayed by an Excel spreadsheet. The no-aid group of novice traders received only the basic private information (Figure 5-2 and Figure 5-3) while the other 16 novice traders receiving additional information which interpreted this information. This additional information included the expected value and the range of possible values for the shares (Figure 5-4 and Figure 5-5).

Critics of information systems have argued that, in aiming to present information that a user requires, such systems often provide misinformation. This produces cognitive overloading (Ackoff, 1967). In this experiment, considerable effort was devoted to designing an aid that had an appropriate format and provided information in a useful form.

Tabular and graphical information presentation formats have been shown to be more useful for displaying information for problem solving than raw data (Chervany and Dickson, 1974; Remus, 1984; Benbasat and Dexter, 1985). Given the nature of the information needed to be communicated to the novice trader, a tabular format with both row and column lines was selected as the most suitable means of increasing readability performance (Wu and Yuan, 2003). Figure 5-4 and Figure 5-5 show a static representation (electronic version dynamically updates each period), for Period 1 and 2 respectively, of the information displayed by the decision aid, which had the intention of providing highly visible and unbiased information. Colours (other than black text on a white background) were used for decision aid text and table cells to promote the quicker identification of important information and enhance readability by distinguishing among information items.

Figure 5-1 – Copy of the trading screen in the FTS

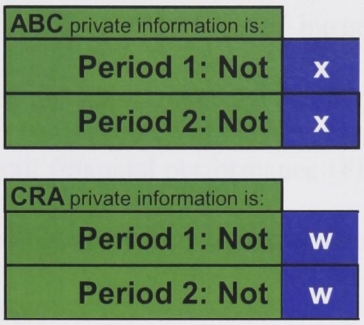

Figure 5-2 - Example of Period 1 Private Information (without Decision Aid)

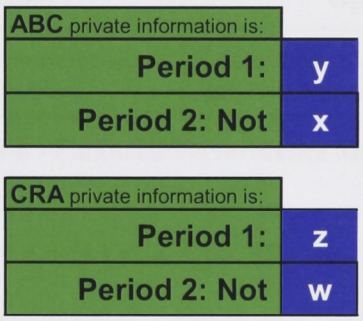

Figure 5-3 - Example of Period 2 Private Information (without Decision Aid)

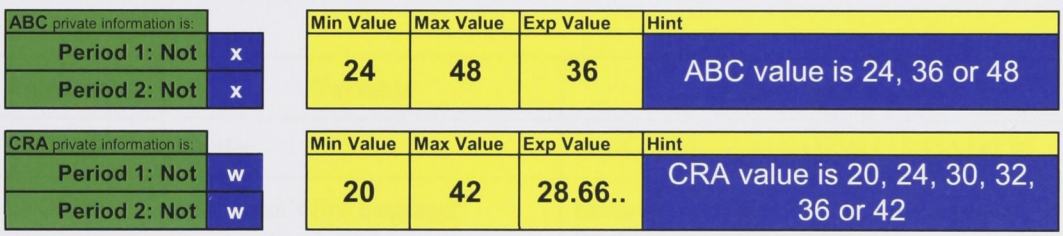

Figure 5-4 – Example of Period 1 Private Information (with Decision Aid)

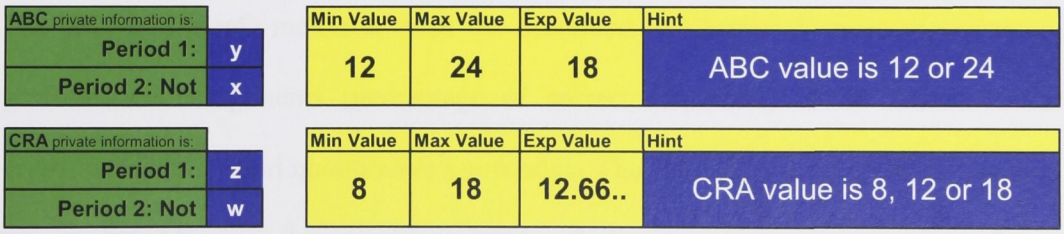

Figure 5-5 - Example of Period 2 Private Information (with Decision Aid)

5.2.4. Design

The second experiment focussed on the effect of introducing a decision aid to the trading environment studied in Experiment 1. As in Experiment 1, the primary dependent variable was overall financial performance (FINP_TOT). It was calculated from the earnings (grade cash) generated by the participants' trades over the length of the entire experiment (6 trials).

Short name	Variable	Operational measure
FINP_TOT	Overall financial performance from trading in 6 trials.	Sum of the participant financial trading performance figures for all 6 trials [±N].

Table 5-6 - Financial Performance Measures

The control covariates were gender (GENDER) and whether English was the participant's first language (ENGLISH). Appendix C shows the survey eliciting this and other data.

Short name	Variable	Operational measure
GENDER	Gender	Gender of the participant [MALE|FEMALE]
ENGLISH	Participant's first language?	Measure of whether English was the primary language understood [YES|NO].

Table 5-7 - Demographic Measures

The four e-bilities® measures used (as described in Chapter 3) were the accuracy performance components (percentage of correct responses) of the measures for crystallised ability and quantitative knowledge. The fluid ability independent variable was excluded because it was not correlated with the dependent variable and was found not to influence financial performance in Experiment 1. Within each of these two cognitive categories, an average value was created from each test's accuracy value.

These two new variables, CRYST and QK, were used as the cognitive independent variables.

Short name	Variable	Operational measure
CRYST	Crystallised ability	Average accuracy of crystallised ability cognitive measures generated from the e-bilities® testing suite [0-100%].
QK	Quantitative knowledge	Average accuracy of quantitative knowledge cognitive measures generated from the e-bilities® testing suite [0-100%].

Table 5-8 - Cognitive Ability Measures

The next independent variable is the number of trading actions, which was measured for all six trials (NUM_ACTS_TOT).

Short name	Variable	Operational measure
NUM_ACTS_TOT	Total number of trading actions in 6 trials.	Sum of all ask, bid, buy and sell actions by participants for all six trials [N].

Table 5-9 - Trading Actions Measures

The treatment group was denoted as AID_USED. Four interaction variables (AID_USED*CRYST, AID_USED*QK and AID_USED*NUM_ACTS) were created to address the research hypotheses.

Short name	Variable	Operational measure
AID_USED	Whether a decision aid was available for use.	Dummy variable for presence of the decision aid [0-No aid, 1-With aid]
AID_USED * CRYST	Interaction effect between Crystallised ability and aid available for use	Product of Crystallised ability values and aid presence dummy variable.
AID_USED * QK	Interaction effect between Quantitative knowledge and aid available for use	Product of Quantitative knowledge values and aid presence dummy variable.
AID_USED * NUM_ACTS	Interaction effect between Number of trading actions and aid available for use	Product of Number of trading actions (decision-making speed) and aid presence dummy variable.

Table 5-10 – Aid Use Measures

The variables used in the regression analysis are summarised in Table 5-11.

Variable Type	Variable Name	Description
Dependent	FINP_TOT	Financial performance
Control	GENDER ENGLISH	Demographics
Independent	CRYST	Crystallised ability
	QK	Quantitative knowledge
	NUM_ACTS_TOT	Number of trading actions
	AID_USED	Decision aid availability
Interaction terms	AID_USED * CRYST	Interaction effect with Crystallised ability
	AID_USED * QK	Interaction effect with Quantitative knowledge
	AID_USED * NUM_ACTS_TOT	Interaction effect with number of trading actions

Table 5-11 –Experiment #2 Variables

5.3. Preliminary Data Analysis

5.3.1. Data Screening

The data was screened to test whether it met the assumptions required for the performance of a regression analysis. First, the consolidated data file was cross-

checked against the original data files from FTS, e-bilities® and the physical paper questionnaires for accuracy and completeness of input. In the case of missing values, the mean was substituted. Two cases had missing quantitative ability values. The mean of 64 per cent derived from the 28 valid results was substituted for the missing values. A third missing value was due to a participant not completing the confidence questions before trading started. The mean value of 3.60 was substituted. All 30 novice traders (16 with and 14 without aid) were used in analysis after this step.

The dependent and independent variables were then screened for outliers, which are defined by Tabachnick and Fidell (2001) as those values with standardised residual values more than 3.3 (or less than -3.3). Most financial performance values met this condition except for one FINP_1H and two FINP_2H outliers where novice traders had very large profits or losses. Due to the relatively small sample size (n=30) and the fact that the observations for three participants were not errors and explained a large amount of the profit (or loss) flow in the sample, it was decided not to exclude these data points.

Further, it can be seen from Table 5-12 that the financial performance variables were not normally distributed and had large standard deviations with a small mean. The large standard deviations were a result of those novice traders with very large profit or loss values. The small mean is due to monetary funds being exchanged, but never destroyed or created (other than the starting position that places the mean slightly above 0). These outliers and non-normality were addressed by transforming the variables to a ranked normal score using Blom's formula (Blom, 1958). While this procedure results in value changes, the changed variable still reflects the underlying

nature of the data. In this case, while there were some values at either extreme, the bulk of the values were distributed around the median (as shown by the original substantially positive kurtosis).

The independent variables were also checked for normality. It can be seen from the descriptive statistics in Table 5-12 that CRYST and NUM_ACTS_TOT do not meet the criteria for normality; their skewness and kurtosis statistics are more than twice the standard error.

	N	Min	Max	Mean	S.D.	Skewness		Kurtosis	
						Stat	S.E.	Stat	S.E.
FINP_TOT	30	-7070.15	7708.34	3.2630	2411.64254	-.560	.427	7.184	.833
CRYST	30	.32	.86	.6605	.12688	-1.258	.427	1.513	.833
QK	30	.17	.92	.6370	.17765	-.575	.427	.222	.833
NUM_ACTS_TOT	30	58.00	2373.00	614.6333	526.98508	2.211	.427	5.328	.833
Valid N (listwise)	30								

Table 5-12 - Descriptive Statistics (before normalisation)

The moderate negative skewness of CRYST was resolved with a reflect and square root transformation. NUM_ACTS was substantially positively skewed, so a logarithmic transformation was applied. Table 5-13 shows the variables after transformations for normality have been applied.

	N	Min	Max	Mean	S.D.	Skewness		Kurtosis	
						Stat	S.E.	Stat	S.E.
T_FINP_TOT	30	-2.0403	2.0403	0.0000	.97279	.000	.427	-.318	.833
T_CRYST	30	.39	.83	.5827	.10168	.787	.427	.820	.833
QK	30	.17	.92	.6370	.17765	-.575	.427	.222	.833
NUM_ACTS_TOT	30	1.76	3.38	2.6618	.34870	-.385	.427	1.092	.833
Valid N (listwise)	30								

Table 5-13 - Descriptive Statistics (after normalisation)

The next step before performing linear regression analysis was to check for multicollinearity and singularity (Tabachnick and Fidell, 2001). Bivariate correlations showed that there were no significant correlations among the independent variables. As for singularity, although the cognitive ability measures in theory do share some common attributes, the e-bilities® tests are designed to measure each attribute separately and not as a combination of the others. With data meeting the required assumptions, a linear regression may be preformed.

5.3.2. Reliability of Instruments

The e-bilities® test suite used for measuring cognitive abilities is the same as that used in Experiment 1 (refer to Section 0).

5.4. Primary Analysis

A standard linear regression model in SPSS v15 was used to test the experimental hypotheses. The endogenous dependent variable is overall financial performance. There were four main exogenous independent variables: crystallised ability (reflect and square root), quantitative knowledge, total trading actions (log) and aid available for use. In addition, there were also the interaction terms of aid usage with the other three variables. The control variables of confidence, understanding, English ability and gender were also found to not correlate with financial performance and were omitted from analysis.

An a priori test was run with G*Power (Faul et al., 2007) to compute the required sample size (Figure 5-6). In order to find a statistically significant relationship in the regression for a large effect (f^2=.35) with seven independent variables, a sample size

of at least 49 is required to achieve power of .80 (p=.05). It is acknowledged that this situation was one of low power.

F tests – Multiple Regression: Omnibus (R^2 deviation from zero)			
Analysis:	A priori: Compute required sample size		
Input:	Effect size f^2	=	0.35
	α err prob	=	0.05
	Power (1–β err prob)	=	.80
	Number of predictors	=	7
Output:	Noncentrality parameter λ	=	17.150000
	Critical F	=	2.242894
	Numerator df	=	7
	Denominator df	=	41
	Total sample size	=	49
	Actual power	=	0.805774

Figure 5-6 - Power analysis - required sample size

Data screening was carried out before the regression analysis. With seven independent variables (4 main and 3 interaction effects), a sample size of 30 is not sufficient for the minimum 5:1 cases to variables ratio suggested by Tabachnick and Fidell (2001). A minimum sample size of 106 ($n > 50 + 8m$) is recommended by Green (1991). However, limits on server processing capacity in an experimental market simulation meant that the use of that number of participants was not feasible. Sensitivity analysis calculated using G*Power found an effect size (f^2) of 0.647 is required with a sample size of 30 (Figure 5-7).

F tests – Multiple Regression: Omnibus (R^2 deviation from zero)			
Analysis:	Sensitivity: Compute required effect size		
Input:	α err prob	=	0.05
	Power (1–β err prob)	=	.80
	Total sample size	=	30
	Number of predictors	=	7
Output:	Noncentrality parameter λ	=	19.401078
	Critical F	=	2.463774
	Numerator df	=	7
	Denominator df	=	22
	Effect size f^2	=	0.646703

Figure 5-7 - Power analysis - required effect size

A previous section described the transformations of the variables to reduce the number of outliers, reduce skewness and improve the normality, linearity and homoscedasticity of the residuals. With the use of the $p < .001$ criterion for Mahalanobis distance, no outliers among the cases were found. The maximum distance value was 20.557, which is below the critical value of 24.322 (7 IVs). No cases within the regression had missing data and no suppressor variables were found ($n = 30$). The resulting scatterplot of the regression standardised residual and regression standardised predicted value for ranked overall financial performance can be seen in Figure 5-8. The normal P-P plot of regression standardised residual shown in Figure 5-9 has points that lie in a reasonably straight line, so normality assumptions appear not to be violated.

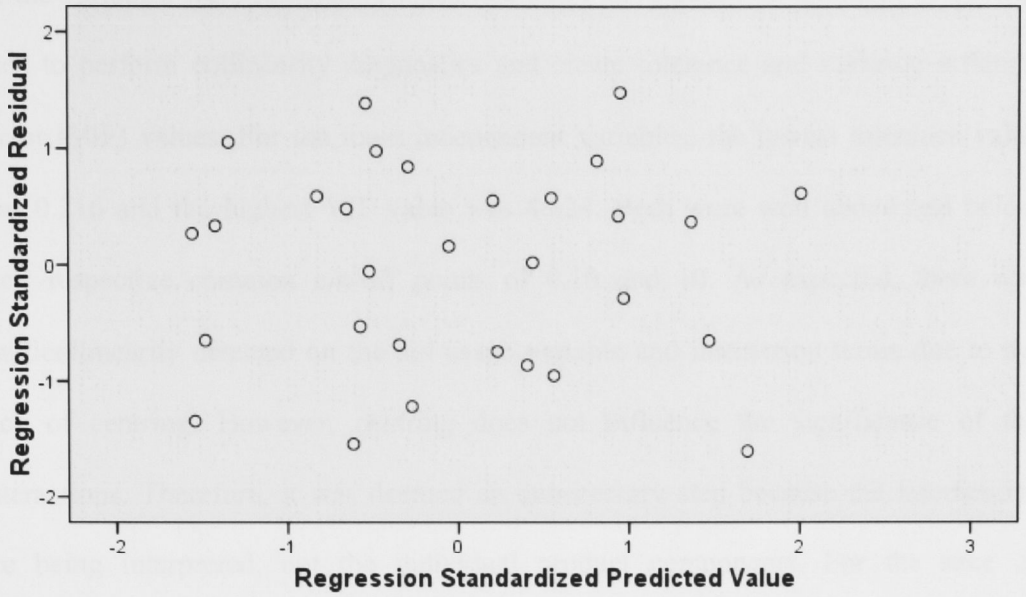

Figure 5-8 - Scatterplot of the Regression Standardised Residual and Regression Standardised Predicted Value for ranked Overall Financial Performance

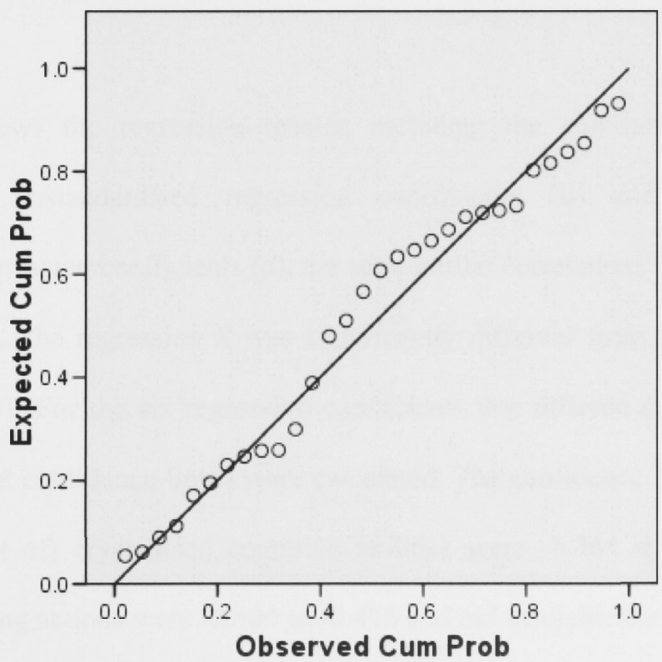

Figure 5-9 - Normal P-P Plot of Regression Standardised Residual

Bivariate correlations were performed to check the existence of multicollinearity among the main independent variables. No values were greater than 0.700. Therefore,

all the variables were retained (Tabachnick and Fidell, 2001). In addition, SPSS was used to perform collinearity diagnostics and create tolerance and variance inflation factor (VIF) values. For the main independent variables, the lowest tolerance value was 0.216 and the highest VIF value was 4.624. Both were well above and below their respective common cut-off points of 0.10 and 10. As expected, there was multicollinearity detected on the aid usage variable and interaction terms due to the lack of centring. However, centring does not influence the significance of the interactions. Therefore, it was deemed an unnecessary step because the interactions are being interpreted, not the individual product components. For the sake of completeness, the analysis was repeated with centred independent variables. As expected, the findings were the same but without multicollinearity (except for the main terms correlating with the interaction effect version).

Table 5-15 shows the regression results, including the correlations among the variables, the unstandardised regression coefficients (B) and intercept, the standardised regression coefficients (β), the semi-partial correlations (sr_i^2) and R^2, and the adjusted R^2. The regression R was significantly different from zero, $F(7, 22) = 10.157$, $p < .001$. For the six regression coefficients that differed significantly from zero, 95 per cent confidence limits were calculated. The confidence limits for (reflect and square root of) crystallised cognitive abilities were -6.364 to 0.264, (log of) number of trading actions were -2.400 to -0.476 and aid available for use were -4.883 to -4.624.

Six of the independent variables contributed significantly to explaining financial performance as ranked: (reflect and square root) crystallised ability ($sr_i^2 = .039$),

number of actions (sr_i^2 = .103), aid available for use (sr_i^2 = .167), (reflect and square root) crystallised ability * aid available for use (sr_i^2 = .036), quantitative knowledge * aid available for use (sr_i^2 = .070) and number of actions * aid available for use (sr_i^2 = .129). The seven independent variables combined contributed another .218 in shared variability. Altogether, over 76 per cent (69% adjusted) of the variability in financial performance was predicted by scores on these six independent variables.

Although the correlation between quantitative knowledge and ranked financial performance was -0.342, QK did not significantly contribute to the regression. Post hoc evaluation of the correlation revealed that it was not significantly different from zero, $F(7, 22) = 0.416$.

Variable Type	Variable Name	Description
Dependent	T_FINP_TOT	Transformed "Financial performance"
Independent	T_CRYST	Transformed "Crystallised ability"
	QK	"Quantitative knowledge"
	T_NUM_ACTS_TOT	Transformed "Number of trading actions"
	AID_USED	Decision aid availability
Interaction terms	AID_USED * T_CRYST	Interaction effect with transformed "Crystallised ability"
	AID_USED * QK	Interaction effect with "Quantitative knowledge"
	AID_USED * T_NUM_ACTS_TOT	Interaction effect with transformed "number of trading actions"

Table 5-14 – Experiment 2 Variable Name Legend for Table 5-15

Variables	T_ FINP_TOT (DV)	T_CRYST	QK	T_NUM_ ACTS_T OT	AID_USED	AID_USED* T_CRYST	AID_USED *QK	AID_USED* T_NUM_ ACTS_TOT	*B*	*β*	sr^2 (unique)
T_CRYST	-.274^								-3.050^	-.319	. 039
QK	.342*	-.139							-.477	-.087	
T_NUM_ACT S_TOT	-.173	-.241^	.160						-1.438**	-.515	.103
AID_USED	.582***	.008	.114	-.223					-9.753***	-5.087	.167
AID_USED* T_CRYST	.515**	.168	.011	-.264^	.973***				4.327^	1.354	.036
AID_USED* QK	.726***	-.138	.441**	-.157	.914***	.841***			3.734*	1.397	. 070
AID_USED* T_NUM_ACT S_TOT	.617***	-.028	.137	-.093	.983***	.944***	.911***		2.200**	3.023	. 129
								Intercept = 5.418			
Means	0.000	.583	.637	2.662	.53	.311	.350	1.381			
Standard deviations	0.973	.102	.178	.349	.507	.304	.364	1.337	R^2 = .764[a]		
									Adjusted R^2 = .688		
									R = .874***		

^ p < .10 * p < .05 ** p < .01 *** p < .001

[a]Unique variability = .545; shared variability = .218

Table 5-15 - Standard Multiple Regression of Cognitive Abilities, Number of Trading Actions and Aid Usage on Financial Performance[12]

[12] Refer to Tabachnick and Fidell (2001) for a detailed explanation of this statistical reporting method.

5.5. Discussion

The purpose of Experiment 2 was to investigate the effect of introducing a decision aid on novice traders. The hypotheses tested were as follows:

H3: *The use of a decision aid by novice traders will lead to higher performance in financial trading.*

H4b: *A decision aid can mitigate the detrimental effects of lower crystallised ability on financial trading performance by novice traders.*

H4c: *A decision aid can mitigate the detrimental effects of lower quantitative knowledge on financial trading performance by novice traders.*

H5: *A decision aid can mitigate the detrimental effects of higher trading speed on financial trading performance by novice traders.*

Figure 5-10 shows the research model for the relevant Experiment 1 hypotheses tested alongside the decision aid manipulation hypotheses tested in Experiment 2 (H1a and H4a concerned Fluid ability, which was removed as a result of the Experiment 1 findings). While H1b, H1c and H2 cannot be interpreted directly due to interaction effects with decision aid usage, the regression results replicate Experiment 1 for the effects of crystallised ability (supported) and quantitative knowledge (not supported) on financial performance. Unlike Experiment 1, Experiment 2 found the number of trading actions to be significant.

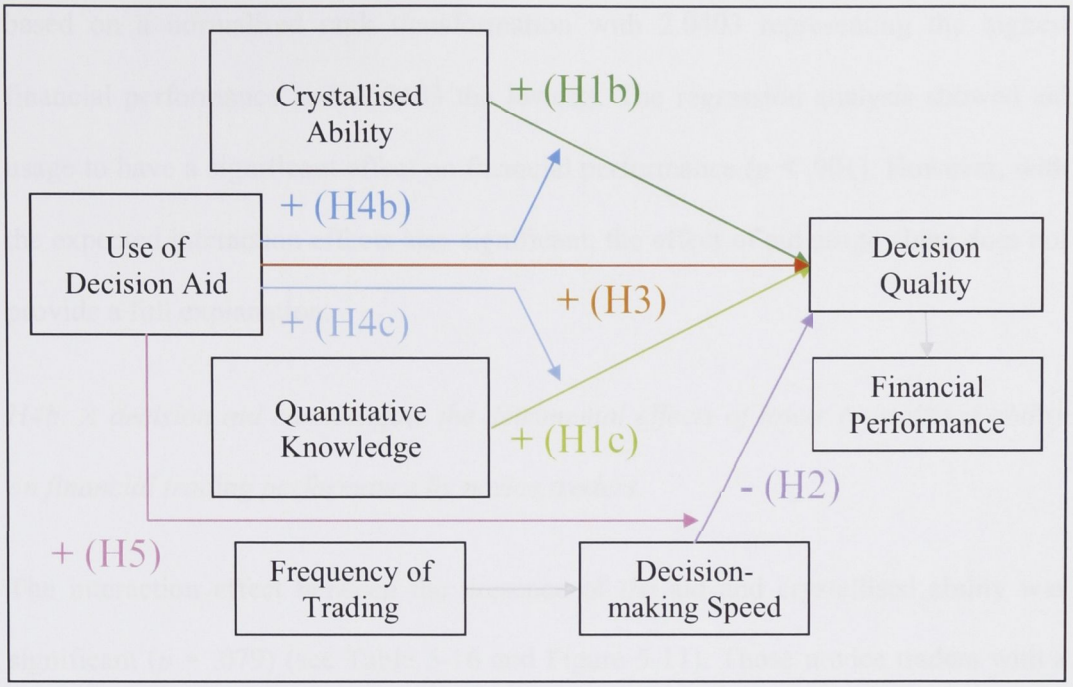

Figure 5-10 - Detailed Experiment 1 + 2 Research Model

The results show that Hypotheses 3 (use of decision aid), 4b (interaction between use of decision aid and crystallised ability), 4c (interaction between use of decision aid and quantitative knowledge) and 5 (interaction between use of decision aid usage and number of trades) were supported. The results are discussed according to each hypothesis.

H3: The use of a decision aid by novice traders will lead to higher performance in financial trading

Performance for the group with the decision aid was significantly higher, as found in the results of the t-test of difference between the financial performance means for the two experimental test groups ($p < .001$). Non-aid users had a mean of -.594 with a 95 per cent confidence interval between 0.933. and -2.122. The aid users had a mean of .520 with a 95 per cent confidence interval of -1.159 and 2.120 respectively (This is

based on a normalised rank transformation with 2.0403 representing the highest financial performance and -2.0403 the lowest). The regression analysis showed aid usage to have a significant effect on financial performance ($p < .001$). However, with the expected interaction effects also significant, the effect of aid usage alone does not provide a full explanation.

H4b: A decision aid can mitigate the detrimental effects of lower crystallised ability on financial trading performance by novice traders.

The interaction effect between the presence of the aid and crystallised ability was significant ($p = .079$) (see Table 5-16 and Figure 5-11). Those novice traders with a higher level of crystallised ability performed better than those with a lower ability in both the aid and no-aid groups. The slopes of the lines in Figure 5-11 indicate that the difference in performance of low crystallised and high crystallised traders is not as great in the aid condition as in the no-aid condition. There is still support for this hypothesis as low crystallised ability traders with decision support performed much better than their no-decision aid equivalents.

	Low Crystallised Ability group	**High Crystallised Ability group**
No aid	-0.71	-0.48
With aid	0.46	0.58

Table 5-16 - Mean Financial Performance (T_FINP_TOT) in each group (split by median)

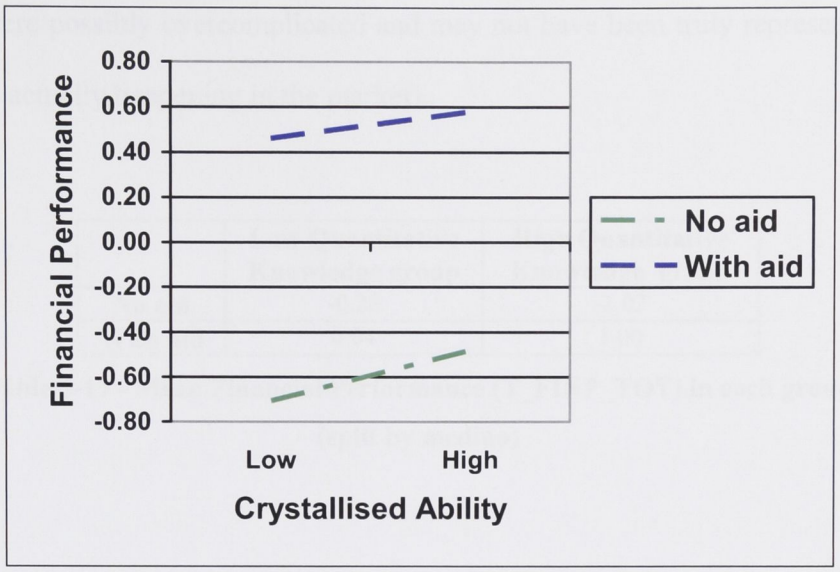

Figure 5-11 - Plot of Financial Performance (T_FINP_TOT) values

H4c: A decision aid can mitigate the detrimental effects of lower quantitative knowledge on financial trading performance by novice traders.

The interaction effect between the presence of the aid and quantitative knowledge was significant (p = .018) (see Table 5-17 and Figure 5-12). Users with the aid outperformed novice traders with similar quantitative ability who did not have the aid. It is interesting to note the direction of the 'no aid' slope. It shows that novice traders without the aid performed worse as their cognitive ability increased. Regardless of whether a novice trader had an aid, traders with a lower cognitive ability had similar mean performance values.

One interpretation of these findings is that the aid not only reduces the burden of part of the decision-making process but may also limit the damage caused by traders being 'too smart for their own good'. Novice traders with the aid and high quantitative knowledge could maximise the benefits of combining the aid with their quantitative skill to increase their performance. Novice traders with similar high levels of quantitative ability but without the aid had to rely upon their own mental models

(which were possibly overcomplicated and may not have been truly representative of what was actually happening in the market).

	Low Quantitative Knowledge group	High Quantitative Knowledge group
No aid	-0.28	-1.02
With aid	0.04	1.00

Table 5-17 - Mean Financial Performance (T_FINP_TOT) in each group (split by median)

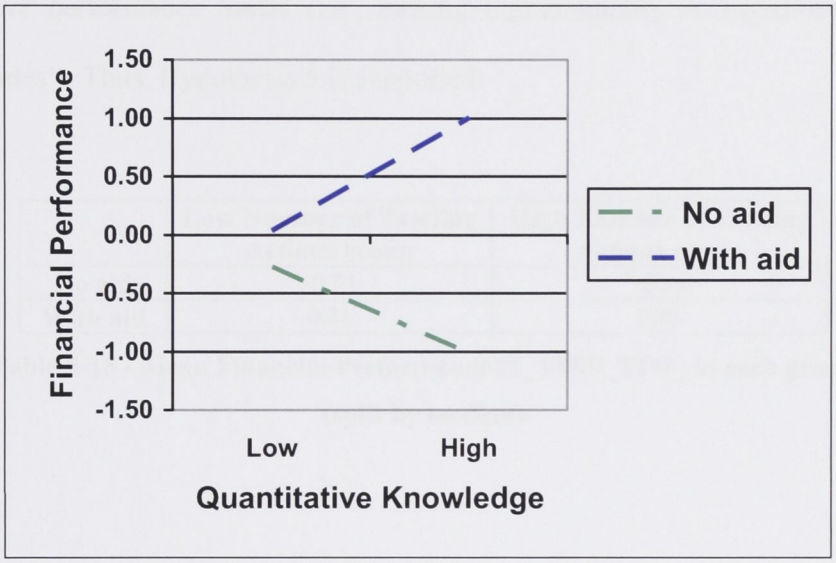

Figure 5-12 - Plot of Financial Performance (T_FINP_TOT) values

The main effect of the number of trading actions was significantly related to decreased performance (p = .005. However, the interaction effects also need to be considered in Hypothesis 5.

H5: A decision aid can mitigate the detrimental effects of higher trading speed on financial trading performance by novice traders.

The interaction effect between the presence of the aid and trading speed was significant (p = 0.002) (see Table 5-18 and Figure 5-13). The novice traders who lacked the aid and undertook high levels of trading performed worse than novice traders with lower levels of trading. This supports the findings of Barber and Odean (2002) that 'the slow do not die first'. In addition to this, novice traders with the decision aid and higher levels of trading action performed better than 'slower' novice traders. It appears that the aid provides a performance advantage regardless of trading speed. Novice traders with more trading actions having a corresponding higher level of positive performance trades (i.e., making higher quality decisions resulting in 'good trades'). Thus, Hypothesis 5 is supported.

	Low Number of Trading Actions group	High Number of Trading Actions group
No aid	-0.34	-0.84
With aid	0.21	0.83

Table 5-18 - Mean Financial Performance (T_FINP_TOT) in each group (split by median)

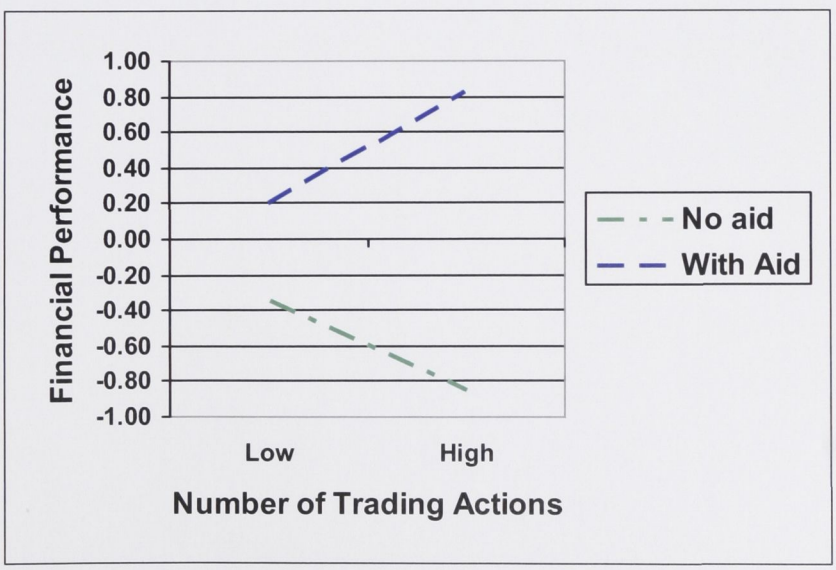

Figure 5-13 - Plot of Financial Performance (T_FINP_TOT) values

5.6. Conclusion

The purpose of this second experiment was to investigate the relationships between cognitive ability, decision-making speed and financial performance when a decision aid was provided to one of the two subject groups. It was found that crystallised ability, quantitative knowledge and number of trading actions did influence financial performance when the novice trader had a decision aid available for use. Other demographics, including gender, age, English ability and prior financial trading experiences were examined as potential covariates, but they showed no significant relationship to trading performance. The understanding derived from Experiment 2 will be further discussed in Chapter 6.

Chapter Six

Conclusions, Limitations and Implications

'The art of being wise is the art of knowing what to overlook.'
– William James

6.1. Introduction

This chapter concludes the thesis by presenting an overview of the work as a whole. First, the objectives and theoretical foundations of the research are summarised. Second, the experimental work undertaken and data analyses performed are outlined. Third, the conclusions resulting from the study are presented and limitations discussed. Fourth, the implications of the research for theory and practice are analysed. Fifth, suggestions for future research are given.

6.2. Objective and Underlying Research Summary

The primary objective of this study was to investigate the performance of novice traders in an online share trading environment and the effects of a decision aid in this environment. The research focused first on determining whether financial trading performance varies with cognitive abilities and speed of trading (decision-making speed). Previous work dealing with the influence of cognitive abilities on share trading is sparse, and results concerning the effect of decision speed have not only varied with the task but been contradictory. This study has practical significance because human decision-making ability is a vital aspect of successful financial trading.

Second, the research investigated whether the provision of decision support in a trading environment would help to overcome problems with high-speed decision-

making and limited cognitive ability. Research in this area is also sparse and possibly goes unreported because of commercial considerations. The current work has practical significance because information overload is a serious problem when valuing securities, particularly for inexperienced investors.

The model tested in this research was based on knowledge of cognitive abilities, human decision-making and decision support systems examined in the context of experimental markets. The cognitive ability perspective led to the prediction that higher cognitive ability would lead to greater financial performance in share trading (Hypotheses H1a, H1b and H1c). Human decision-making theory led to the prediction that the higher the number of trades in a given period, the lower the financial performance (Hypothesis H2).

Research with decision support systems led to the prediction that use of a decision aid would also increase trading performance (Hypothesis H3). When decision aid use was combined with cognitive ability, it was predicted the decision aid would mitigate the detrimental effects on financial performance of low cognitive abilities (Hypotheses H4a and H4b). Decision aid use was also combined with decision speed in the prediction that aid users would be able to trade more frequently and mitigate trading speed effects that would lead to a reduction in financial performance (Hypothesis H5).

6.3. Experiment and Data Analysis Summary

Two experiments were undertaken in laboratory settings. Table 6-1 shows the variables involved in each experiment.

	First Experiment	Second Experiment
Dependent Variable		
Financial Performance	✓	✓
Independent Variables		
Fluid Ability	✓	-
Crystallised Ability	✓	✓
Quantitative Knowledge	✓	✓
Number of Trading Actions	✓	✓
Decision Aid Availability	-	✓

Table 6-1 - Variables Involved in Each Experiment

Participants in both experiments used financial trading software to trade shares in an experimental market where they had their financial performance measured. Cognitive abilities were measured in a preliminary test. In Experiment 1, the provision of decision support was held constant, with no support being made available. In Experiment 2, decision support was manipulated, with approximately 50 per cent of the participants being given access to a decision aid. Age, gender, prior trading experience, understanding and confidence were measured as potential control variables. However, the initial analysis indicated that they had no effect, so they were excluded from the primary analysis.

6.4. Conclusions

The primary research question for this study was as follows:

> *What is the relationship between decision support, cognitive abilities and time constraints and how do these factors affect financial performance in share trading by novice traders?*

This produced the following questions of interest regarding novice traders:

- Do the cognitive abilities of traders influence their performance in a share market trading context where high-speed decision-making is required?
- Do time constraints influence performance in a decision-making environment?
- Can a decision support tool (aid) improve the performance of novice traders in a share market environment, a situation where decision-making is constrained by time and traders have varying cognitive abilities?

Five propositions were developed from theory to address these questions. Table 6-2 summarises the hypotheses and the support obtained for them. The remainder of this section discusses the support for each hypothesis.

		Support	
	Summarised Hypothesis	**First Experiment**	**Second Experiment**
H1a	A higher level of fluid ability will lead to higher performance in financial trading.	Not supported	Omitted
H1b	A higher level of crystallised ability will lead to higher performance in financial trading.	Supported	Supported*
H1c	A higher level of quantitative knowledge will lead to higher performance in financial trading.	Not supported	Only in aid conditions*
H2	Higher decision-making speed will lead to lower performance in financial trading.	Not supported	Only without aid*
H3	The use of a decision aid by novice traders will lead to higher performance in financial trading.	N/A	Supported*
H4a	A decision aid can mitigate the detrimental effects of lower crystallised ability on financial trading performance.	N/A	Supported
H4b	A decision aid can mitigate the detrimental effects of lower quantitative knowledge on financial trading performance.	N/A	Supported
H5	A decision aid can mitigate the detrimental effects of higher trading speed on financial trading performance.	N/A	Supported
* Evidence shown in interaction effects			

Table 6-2 – Summary of Support Obtained for the Research Hypotheses

When considering cognitive abilities without the presence of a decision aid (Experiment 1), the findings found that crystallised ability had a significant positive relationship with financial performance (higher crystallised ability leads to better trading performance). Fluid ability and quantitative knowledge were not significant. Likewise, the number of trading actions (decision-making speed) was found not to have a significant relationship with performance, although there was some evidence for this relationship when outlying values were included.

Not all of these findings held true when a decision aid was given to one group (Experiment 2). While crystallised ability remained as the only significant measure of cognitive ability, the number of trading actions was significant. However, with the existence of significant interaction effects in the model, interpreting the main effect alone was not advised. Instead, the interaction effects of aid usage with each of the main effects gave a much clearer picture of novice trader characteristics.

The aid use main effect by itself was significant in the regression analysis. In all conditions, novice traders who had the decision aid performed better than those without it. Decision aid users with higher cognitive abilities or decision-making speed also had higher financial performance. All of these findings were as hypothesised.

There were interesting results for novice traders who did not have the aid. As expected, they performed worse the more they traded. Contrary to predictions, novice traders with no aid and higher levels of quantitative abilities performed worse than novice traders with lower abilities. That higher quantitative abilities was actually a hindrance for financial performance deserves further research. It is suggested that the decision aid acted as a mental outer boundary for the decision-making model; novice traders lacking the aid and having more cognitive abilities attempted more than they could handle in the decision-making process. Novice traders with lower cognitive ability exerted less cognitive effort and most likely focused on a few pieces of information. This created a smaller bounded decision model than the one used by their fellow non-aid novice traders who had higher cognitive abilities.

6.5. Limitations

This section discusses potential limitations to the study using the terminology of Cook and Campbell (1979).

6.5.1.1. Statistical Conclusion Validity

Statistical conclusion validity 'refers to inferences about whether it is reasonable to presume covariation given a specified α level and the obtained variances' (Cook and Campbell, 1979, p. 37). The seven major threats to statistical conclusion validity identified by Cook and Cambell (1979) were controlled for.

Within the analysis of each experiment, the statistical power of each test was discussed separately. Future studies would benefit from a large number of participants, provided a suitable experimental market can be simulated. Given the low number of participants, all the statistical tests were performed so that they complied with the relevant assumptions underlying their use.

Though it is possible that significant differences were found by chance, the analysis performed did not result in any 'fishing' for such differences. The controversial nature of stepwise regression precluded it from being used instead of normal linear regression. In addition, all significant results were reported at the more conservative two-tailed rather than one-tailed alpha levels, even though the hypotheses were directional.

As discussed in Chapter 2, the e-bilities® test suite is based on the Cattell-Horn-Carroll model and has been internally validated for use in employment, education and health settings.

To minimise the effect of any inequality in how the participants were treated, the experiments were scripted and participant behaviour actively monitored to ensure there was no breach of experimental conditions. All participants received the same training and traded in the same experimental share market. They were all administered identical questions and received the same standard documentation.

Prior to the experiments in this study, there were more than five other sessions held where participants were observed using FTS in an experimental setting (and more than 25 sessions after). The understanding gained from these experiences combined with an enclosed controlled computer lab environment allowed the treatment to be precisely applied. These experiences are described in Foster et al. (2004, 2006).

Threats from the random heterogeneity of respondents were controlled to some extent by the number of measures used to test covariates (age, prior experience and English as a first language)

6.5.1.2. Internal Validity

Cook and Campbell (1979) also identify many potential threats to internal validity. Randomly assigning participants to separate rooms minimises many, but not all, threats. In Experiment 1, every participant received the same treatment. Experiment 2

had two separate groups, and participants received the same treatment within their respective group (i.e., they had or did not have the decision aid).

Situating the experiment within access controlled computer labs meant that the participants were insulated from outside influences. The choice of dependent variable, financial performance, also mitigated the effect of external influences because all information was directly derived from documentation and onscreen computer displays.

Part of the aim of testing participant understanding was to measure whether it changed after trading. The participants were twice exposed to the same questions. However, this exposure was required to longitudinally capture any change in their understanding.

The private information each participant received was randomly assigned depending upon the random dividend payment selection for the trading trial. Statistically, it is possible that two trials within an experiment could have been identical, but the likelihood is low enough that it would not have adversely affected performance.

Apart from training in a similar setting, it was the first time that any of the participants had participated in such an experiment. The participants were randomly assigned to each of the two computer labs. In both experiments, the students within each group received the same treatment and used computer systems with the same specifications. All participants included in the experiment completed the full treatment and were not made aware of any difference in their treatment. All missing

data from the questionnaires was identified in screening and changes were made as appropriate.

No participant was permitted to communicate, either verbally or textually, with another participant once they entered the computer lab. Part of the share market structure relies upon non-communication to enforce the privacy of share information.

All participants received a minimum payment of $20 Australian Dollars to offset the cost of the two hours they participated in the experiment. The participants were also able to increase the payment by acquiring financial wealth above a reasonable random hurdle figure. This reward system provided incentives to trade profitably and, in particular, to achieve a profit in each trial (Foster et al., 2004)

6.5.1.3. Construct Validity

The primary role of Experiment 1 was to determine the influence of the constructs in a controlled environment so that the results of Experiment 2 (application of a decision aid treatment) could be better understood. The nine major threats to construct validity identified by Cook and Campbell (1979) and how they were controlled for are discussed in the following section.

The choice of terms, such as 'financial performance' and 'confidence', were carefully considered and explained. It is difficult to quantitatively measure a person's beliefs and know what level of confidence (optimal, under or over) will lead to a positive financial outcome. It was also not feasible to incorporate a complete self-efficacy

framework into the research model. Instead, the participants reported on a scale how confident they believed they were.

Multiple constructs were used to investigate causal influence. The participants were informed that the purpose of the experiment was to investigate the impact of electronic trading systems and information dispersion. They were told there may be changes to the trading system, support tools available and private information for each participant. They were also told that they should attempt to maximise their trading performance. From the questionnaires, they may have been able to infer that the variables of confidence and understanding were of interest to the researchers. Regardless of what the participants believed, they were not privy to the hypotheses being investigated. As far as they knew, all the participants were receiving the same treatment. Each person participated in only one experimental session and underwent no repeat testing.

From the participants' viewpoint, they were not being personally evaluated by experts but interacting with peers in a common scenario using the computer. There was very little supervisor/participant interaction beyond initial training and the scripted experiment orders. All the paper based questionnaires used closed questions and the electronic market information was collected by the market server.

The experiment involved no direct face-to-face interaction with the participants where leading questions could be asked. The trading data was collected by the market server, and the questionnaire data was transcribed into discrete ordinal and correct/incorrect dichotomous values.

The list of independent variables considered for measurement was derived from existing literature and experienced researchers from varying disciplines (information systems, behavioural finance, management science, cognitive psychology and statistics). Cognitive ability was identified as the primary construct of interest. Three aspects of it were measured to determine its effect on financial performance. The number of trading actions was also of interest because trading frequency can affect financial performance in a number of ways.

6.5.1.4. External Validity

As with any lab experiment using controlled conditions, maximising external validity was a concern. The three major threats to external validity identified by Cook and Campbell (1979) and how they were controlled for are discussed below.

Students from a large first year finance course were invited to participate in the experiment. While this may result in a bias due to 'better' students being more likely to volunteer, students explained that they signed up for a variety of reasons (e.g., financial incentive, new experience, relevance to studies, social interaction and peer pressure). These reasons also reflect motivating factors for real-life traders in their decision to trade shares on the Internet (O'Brien and Srivastava, 1991).

The target population was an issue, particularly with regard to the level of academic ability. The participants in the experiments were academically competent, and this is consistent with their meeting the relatively high university entrance requirements. Finance students were the focus because it was determined that they would be more representative of those likely to take up share trading. They would also be more likely

to have the experience to understand the task required of them—share trading in an experimental share market. Experimental finance studies also typically use undergraduate students to represent novice traders (Moldovan et al., 2003; Arnold et al., 2004). The use of undergraduate finance students in this study allowed them to gain a better understanding of the coursework concepts they were introduced to a few weeks prior to the period in which the experiments were held. Through careful design of the experiment control conditions, the nature of the participants is less important.

With the study focussing primarily on the effect of cognitive abilities and decision support on financial performance with novice traders, it was deemed that a computer lab setting was preferable to the participants being situated in a more general office/home environment. Though the market software could theoretically work over the Internet, the organisational logistics and loss of control over inappropriate participant behaviour that this approach would evoke made this unfeasible.

The choice of experiment time was a function of lab availability during the teaching semester and when the majority of participants had sufficient free time to take part in the experiment. The experiments were conducted early to mid-afternoon to minimise the effect of mental and physical tiredness on the results. To the researcher's best knowledge, no significant historical events unduly influenced the findings.

6.6. Theoretical Implications

Although pertaining only to novice traders, these findings have several theoretical implications. In particular, they strengthen the case for including more psychological decision-making research into behavioural finance. While this study was not

exhaustive in its application of cognitive testing, the statistical analyses show that certain aspects of cognitive ability appear to be more influential than others. This is the first known study investigating such an issue, and it is clear that there is need for further studies to clarify these findings.

Barber and Odean (2002) argued that further research needed to be undertaken into the proposition that experienced traders (compared to the novices in this study) who trade more often perform worse due to overconfidence. This study found no significant relationship between novice traders' confidence levels and their financial performance. Barber and Odean (2002) also proposed that traders ignored transaction costs (numerous small trades carry excessive transaction cost overheads). While this study had transaction costs set to zero, the trading behaviour exhibited in the experiments partially supports this. Without support from a decision aid, high levels of trading actions resulted in either highly positive (believed to be quality decision-making) or highly negative trading performance (believed to be inferior decision-making). There was no significant relationship found to allow the direction of financial performance to be predicted solely by the number of trading actions. This may due to a confounding effect of decision quality where many decisions can be beneficial for financial performance if they are of high quality. It can also be said that many poor decisions would be detrimental to financial performance. This finding was clarified in the second experiment, where the introduction of an aid allowed aid users to consistently (on average) create positive wealth while non-aid users consistently lost wealth.

This significant relationship between aid usage, trading actions, cognitive abilities and financial performance supports the well-understood stance that maintaining quality decision-making at high speed is something to strive for. The influence of other external factors, such as time pressure and stress, may also be mitigated by the use of a decision aid.

6.7. Policy and Practice Implications

This research has several practical implications. First, while the experimental setting of the study makes the direct translation of the findings to the real world less applicable, it does demonstrate the need for financial advisors to understand the cognitive abilities of a novice trader (and potentially experienced traders). Professional day traders are often profiled for certain personality traits that firms consider more attractive for the tasks required. Recreational investors are rarely subject to such scrutiny. Understanding what parts of cognitive ability need more support than others will increase trading efficiency and make trading goals more obtainable, be it lowering risk or increasing returns.

Share markets are risky at the best of times, and the level of risk is indicative of potential returns. In general, the higher the returns, the higher the risk. If decision aids can mitigate some of the perceived risk and increase trading activity, small investor portfolios for novice traders may progress beyond investment in 'buy and hold' dividend bearing blue chip securities.

6.8. Future research

The thought processes of the human mind involve much more than what has been investigated in this study. Only four cognitive tests available in e-bilities® were used in this study. While these measures were carefully chosen, many other measures exist that may influence financial performance in a trading environment.

The realism of the experimental market also needs further development. This study used short periods where trading behaviour was compressed and with novice traders as participants. A replication performed over a significantly longer time, where securities are traded in a market that more realistically mirrors the ASX or NYSE et cetera is encouraged, with both novice and experienced traders. The findings would be greatly enhanced if a much larger sample size were used, treatment groups were selected based on their cognitive abilities and a more extensive analysis were undertaken with respect to the decision support capability of trading tools.

6.9. Summary

This chapter has presented a summary of the research and the conclusions of the research. It has also explained the limitations of that research. The implications for theory and practice were also discussed along with suggestions for future research.

This research has contributed to knowledge in the following ways. First, it has identified that a person's cognitive ability does influence his or her trading performance. This has been assumed but never demonstrated prior to this study. In particular, this research has shown that crystallised intelligence has the greatest influence on trading performance and that quantitative knowledge is also influential in certain circumstances.

Second, this research has shown that the speed of decision-making reliably predicts a novice trader's financial performance. Unaided novice traders performed worse on average the more they traded. While this did not appear to be attributed to overconfidence, as Barber and Odean (2002) would suggest, it does reflect the negative consequences of excessive speculative trading (even more so if these experimental markets had transaction costs enabled). While the setting used in this study is substantially different, the second experiment does show that higher decision quality rather than lower trading quantity is more closely linked to positive performance. This furthers the findings of Barber and Odean (2002) by showing that frequent quality trades benefit financial performance (as one would expect).

Finally, this research has shown that decision support plays a significant role in trading performance. Users of the aid performed more strongly (on average), and those with both higher cognitive abilities and increased levels of trading further improved their performance.

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Appendix A

Experiment 1 Private Information

Information	Time into P	Stock1 Info1	Stock1 Info2	Stock1 Info3
Trial 1	0	Per 1: Not y Per 2: Not x	Per 1: Not y Per 2: Not z	Per 1: Not z Per 2: Not x
Period 2	0	Per 1 x Per 2: Not x	Per 1 x Per 2: Not z	Per 1 x Per 2: Not x
Trial 2	0	Per 1: Not x Per 2: Not x	Per 1: Not x Per 2: Not z	Per 1: Not y Per 2: Not x
Period 2	0	Per1: z Per 2: Not x	Per1: z Per 2: Not z	Per1: z Per 2: Not x
Trial 3	0	Per 1: Not x Per 2: Not x	Per 1: Not x Per 2: Not z	Per 1: Not y Per 2: Not x
Period 2	0	Per1: z Per 2: Not x	Per1: z Per 2: Not z	Per1: z Per 2: Not x
Trial 4	0	Per 1: Not x Per 2: Not x	Per 1: Not x Per 2: Not z	Per 1: Not y Per 2: Not x
Period 2	0	Per1: z Per 2: Not x	Per1: z Per 2: Not z	Per1: z Per 2: Not x
Trial 5	0	Per 1: Not x Per 2: Not x	Per 1: Not x Per 2: Not y	Per 1: Not y Per 2: Not x
Period 2	0	Per1: z Per 2: Not x	Per1: z Per 2: Not y	Per1: z Per 2: Not x
Trial 6	0	Per 1: Not x Per 2: Not x	Per 1: Not x Per 2: Not y	Per 1: Not y Per 2: Not x
Period 2	0	Per1: z Per 2: Not x	Per1: z Per 2: Not y	Per1: z Per 2: Not x
Trial 7	0	Per 1: Not x Per 2: Not x	Per 1: Not x Per 2: Not y	Per 1: Not y Per 2: Not x
Period 2	0	Per1: z Per 2: Not x	Per1: z Per 2: Not y	Per1: z Per 2: Not x
Trial 8	0	Per 1: Not y Per 2: Not x	Per 1: Not y Per 2: Not z	Per 1: Not z Per 2: Not x
Period 2	0	Per 1 x Per 2: Not x	Per 1 x Per 2: Not z	Per 1 x Per 2: Not x

Stock1 Info4	Stock1 Info1	Stock1 Info2	Stock1 Info3
Per 1: Not z Per 2: Not z	Per 1: Not y Per 2: Not x	Per 1: Not y Per 2: Not z	Per 1: Not z Per 2: Not x
Per 1 x Per 2: Not z	Per 1 x Per 2: Not x	Per 1 x Per 2: Not z	Per 1 x Per 2: Not x
Per 1: Not y Per 2: Not z	Per 1: Not x Per 2: Not x	Per 1: Not x Per 2: Not z	Per 1: Not y Per 2: Not x
Per1: z Per 2: Not z	Per1: z Per 2: Not x	Per1: z Per 2: Not z	Per1: z Per 2: Not x
Per 1: Not y Per 2: Not z	Per 1: Not x Per 2: Not x	Per 1: Not x Per 2: Not z	Per 1: Not y Per 2: Not x
Per1: z Per 2: Not z	Per1: z Per 2: Not x	Per1: z Per 2: Not z	Per1: z Per 2: Not x
Per 1: Not y Per 2: Not z	Per 1: Not x Per 2: Not x	Per 1: Not x Per 2: Not z	Per 1: Not y Per 2: Not x
Per1: z Per 2: Not z	Per1: z Per 2: Not x	Per1: z Per 2: Not z	Per1: z Per 2: Not x
Per 1: Not y Per 2: Not y	Per 1: Not x Per 2: Not x	Per 1: Not x Per 2: Not y	Per 1: Not y Per 2: Not x
Per1: z Per 2: Not y	Per1: z Per 2: Not x	Per1: z Per 2: Not y	Per1: z Per 2: Not x
Per 1: Not y Per 2: Not y	Per 1: Not x Per 2: Not x	Per 1: Not x Per 2: Not y	Per 1: Not y Per 2: Not x
Per1: z Per 2: Not y	Per1: z Per 2: Not x	Per1: z Per 2: Not y	Per1: z Per 2: Not x
Per 1: Not y Per 2: Not y	Per 1: Not x Per 2: Not x	Per 1: Not x Per 2: Not y	Per 1: Not y Per 2: Not x
Per1: z Per 2: Not y	Per1: z Per 2: Not x	Per1: z Per 2: Not y	Per1: z Per 2: Not x
Per 1: Not z Per 2: Not z	Per 1: Not y Per 2: Not x	Per 1: Not y Per 2: Not z	Per 1: Not z Per 2: Not x
Per 1 x Per 2: Not z	Per 1 x Per 2: Not x	Per 1 x Per 2: Not z	Per 1 x Per 2: Not x

Stock1 Info4	Stock1 Info1	Stock2 Info1	Stock2 Info2
Per 1: Not z Per 2: Not z	Per 1: Not y Per 2: Not x	Per 1: Not w Per 2: Not x	Per 1: Not w Per 2: Not y
Per 1 x Per 2: Not z	Per 1 x Per 2: Not x	Per 1: z Per 2: Not x	Per 1: z Per 2: Not y
Per 1: Not y Per 2: Not z	Per 1: Not x Per 2: Not x	Per 1: Not w Per 2: Not w	Per 1: Not w Per 2: Not x
Per1: z Per 2: Not z	Per1: z Per 2: Not x	Per 1: z Per 2: Not w	Per 1: z Per 2: Not x
Per 1: Not y Per 2: Not z	Per 1: Not x Per 2: Not x	Per 1: Not w Per 2: Not w	Per 1: Not w Per 2: Not x
Per1: z Per 2: Not z	Per1: z Per 2: Not x	Per 1: x Per 2: Not w	Per 1: x Per 2: Not x
Per 1: Not y Per 2: Not z	Per 1: Not x Per 2: Not x	Per 1: Not w Per 2: Not w	Per 1: Not w Per 2: Not y
Per1: z Per 2: Not z	Per1: z Per 2: Not x	Per 1: x Per 2: Not w	Per 1: x Per 2: Not y
Per 1: Not y Per 2: Not y	Per 1: Not x Per 2: Not x	Per 1: Not x Per 2: Not w	Per 1: Not x Per 2: Not y
Per1: z Per 2: Not y	Per1: z Per 2: Not x	Per 1: w Per 2: Not w	Per 1: w Per 2: Not y
Per 1: Not y Per 2: Not y	Per 1: Not x Per 2: Not x	Per 1: Not x Per 2: Not w	Per 1: Not x Per 2: Not x
Per1: z Per 2: Not y	Per1: z Per 2: Not x	Per 1: w Per 2: Not w	Per 1: w Per 2: Not x
Per 1: Not y Per 2: Not y	Per 1: Not x Per 2: Not x	Per 1: Not w Per 2: Not w	Per 1: Not w Per 2: Not y
Per1: z Per 2: Not y	Per1: z Per 2: Not x	Per 1: y Per 2: Not w	Per 1: y Per 2: Not y
Per 1: Not z Per 2: Not z	Per 1: Not y Per 2: Not x	Per 1: Not x Per 2: Not w	Per 1: Not x Per 2: Not x
Per 1 x Per 2: Not z	Per 1 x Per 2: Not x	Per 1: w Per 2: Not w	Per 1: w Per 2: Not x

Stock2 Info3	Stock3 Info4	Stock2 Info5	Stock2 Info6
Per 1: Not w Per 2: Not z	Per 1: Not x Per 2: Not x	Per 1: Not x Per 2: Not y	Per 1: Not x Per 2: Not z
Per 1: z Per 2: Not z	Per 1: z Per 2: Not x	Per 1: z Per 2: Not y	Per 1: z Per 2: Not z
Per 1: Not w Per 2: Not y	Per 1: Not x Per 2: Not w	Per 1: Not x Per 2: Not x	Per 1: Not x Per 2: Not y
Per 1: z Per 2: Not y	Per 1: z Per 2: Not w	Per 1: z Per 2: Not x	Per 1: z Per 2: Not y
Per 1: Not w Per 2: Not z	Per 1: Not y Per 2: Not w	Per 1: Not y Per 2: Not x	Per 1: Not y Per 2: Not z
Per 1: x Per 2: Not z	Per 1: x Per 2: Not w	Per 1: x Per 2: Not x	Per 1: x Per 2: Not z
Per 1: Not w Per 2: Not z	Per 1: Not y Per 2: Not w	Per 1: Not y Per 2: Not y	Per 1: Not y Per 2: Not z
Per 1: x Per 2: Not z	Per 1: x Per 2: Not w	Per 1: x Per 2: Not y	Per 1: x Per 2: Not z
Per 1: Not x Per 2: Not z	Per 1: Not y Per 2: Not w	Per 1: Not y Per 2: Not y	Per 1: Not y Per 2: Not z
Per 1: w Per 2: Not z	Per 1: w Per 2: Not w	Per 1: w Per 2: Not y	Per 1: w Per 2: Not z
Per 1: Not x Per 2: Not y	Per 1: Not y Per 2: Not w	Per 1: Not y Per 2: Not x	Per 1: Not y Per 2: Not y
Per 1: w Per 2: Not y	Per 1: w Per 2: Not w	Per 1: w Per 2: Not x	Per 1: w Per 2: Not y
Per 1: Not w Per 2: Not z	Per 1: Not x Per 2: Not w	Per 1: Not x Per 2: Not y	Per 1: Not x Per 2: Not z
Per 1: y Per 2: Not z	Per 1: y Per 2: Not w	Per 1: y Per 2: Not y	Per 1: y Per 2: Not z
Per 1: Not x Per 2: Not y	Per 1: Not y Per 2: Not w	Per 1: Not y Per 2: Not x	Per 1: Not y Per 2: Not y
Per 1: w Per 2: Not y	Per 1: w Per 2: Not w	Per 1: w Per 2: Not x	Per 1: w Per 2: Not y

Stock2 Info7	Stock3 Info8	Stock2 Info9
Per 1: Not y Per 2: Not x	Per 1: Not y Per 2: Not y	Per 1: Not y Per 2: Not z
Per 1: z Per 2: Not x	Per 1: z Per 2: Not y	Per 1: z Per 2: Not z
Per 1: Not y Per 2: Not w	Per 1: Not y Per 2: Not x	Per 1: Not y Per 2: Not y
Per 1: z Per 2: Not w	Per 1: z Per 2: Not x	Per 1: z Per 2: Not y
Per 1: Not z Per 2: Not w	Per 1: Not z Per 2: Not x	Per 1: Not z Per 2: Not z
Per 1: x Per 2: Not w	Per 1: x Per 2: Not x	Per 1: x Per 2: Not z
Per 1: Not z Per 2: Not w	Per 1: Not z Per 2: Not y	Per 1: Not z Per 2: Not z
Per 1: x Per 2: Not w	Per 1: x Per 2: Not y	Per 1: x Per 2: Not z
Per 1: Not z Per 2: Not w	Per 1: Not z Per 2: Not y	Per 1: Not z Per 2: Not z
Per 1: w Per 2: Not w	Per 1: w Per 2: Not y	Per 1: w Per 2: Not z
Per 1: Not z Per 2: Not w	Per 1: Not z Per 2: Not x	Per 1: Not z Per 2: Not y
Per 1: w Per 2: Not w	Per 1: w Per 2: Not x	Per 1: w Per 2: Not y
Per 1: Not z Per 2: Not w	Per 1: Not z Per 2: Not y	Per 1: Not z Per 2: Not z
Per 1: y Per 2: Not w	Per 1: y Per 2: Not y	Per 1: y Per 2: Not z
Per 1: Not z Per 2: Not w	Per 1: Not z Per 2: Not x	Per 1: Not z Per 2: Not y
Per 1: w Per 2: Not w	Per 1: w Per 2: Not x	Per 1: w Per 2: Not y

Appendix B

Experiment 1 Consent Form

EXPERIMENT CONSENT FORM – 23rd October 2003

The research is designed to test the impact of the introduction of electronic trading systems. In doing so it will touch on the impact of trading systems and information dispersion on individuals and their investment and trading decisions. We have chosen to use an experimental approach as this allows a more controlled environment for the study of individual reaction to financial systems and financial information. The experiments will consist of a market where each participant is given the market ground rules and the participants then trade on a computer system. Each participant is given limited information and the participants can learn from the other participants' trading behaviour to improve their own trading positions. There will be various arrangements of this basic theme with variation in the trading area that students use and in the tools and support systems that the students are able to use.

During the experiment you will complete multiple confidence questionnaires and you will take part in a market share trading game where participants are given some information and then they trade in a market environment with the objective of maximising profits from the trades. The experiment will last about 2 hours and all key-strokes will be recorded for later analysis. There will be no way of linking experimental information back to an individual as each participant is allocated an arbitrary 6-character trader code and no further identifying information is maintained in our records.

Before taking part in this experiment you are requested to sign this form, indicating that you give consent to be part of the experiment and that you give consent for the collection and analysis of both the trading data generated from your trades and the multiple confidence questionnaires.

Please read and sign the following before the experiment commences.

I understand that:
I can withdraw from the experiment at any time;
I will not be placed at risk as a consequence of my participation in this research;
that the experiment is web-based and I am aware that this is not a secure medium;
Talking and communicating with any of the other participants is not allowed during the experiment, since doing so could potentially invalidate the results of the experiment.

Further, I have been given an information sheet and instructions with details of the project and I have also been given the opportunity to ask questions and received satisfactory answers about the research project.

THIS IS TO CERTIFY THAT I HEREBY AGREE TO PARTICIPATE AS A VOLUNTEER IN THE ABOVE NAMED RESEARCH.

If any of the following details are incorrect, please cross it out and write the correct details above

Name (printed) : Xxxxx Xxxxx Signature : _____

Student number : uXXXXXX ID# : 001240

Confidentiality
All information will be treated in a confidential manner. Results will always be reported in such a way that the anonymity of participants is preserved. Your participation is completely voluntary and you may leave this experiment at any time.

Important contact details
If there are any questions at all about the experiment please contact Alex Richardson (Alex.Richardson@anu.edu.au) or Richard Heaney, the chief investigator, (Richard.Heaney@rmit.edu.au).
In particular, if there are any ethical concerns concerning the experiment please contact Sylvia Deutsch (Sylvia.Deutsch@anu.edu.au) of the ANU Human Research Ethic Committee

Experiment 1 Procedure Sheet

Experiment Procedures Sheet (23rd October 2003)

FTS Trading Name: 001240

Steps to follow:

1. Log onto the computer using the following account details:

   Username: a164768
   Password: ftsuser

While you wait for PC to login, read and sign the consent form, read section 1.0 (Introduction) and then read section 2.0 (Experiment Evaluation Forms) of the Experiment Explanation Form.

2. Once your PC is logged in and ready, you can complete ***Experiment Evaluation Form #1*** on the GREEN piece of paper.

Once you finish the first questionnaire, you may then continue onto the next step.

Preparation for Trading Game:-

3. Double-click on "My Computer" and then double-click the H: drive. Double-click on "eftsTrader1.exe" to load the Trading client software. The "Market IP Address" will be written on the room's whiteboard. When you are ready, you may now:
   a. Enter the "Market IP Address" for the tutorial (as provided by the Experiment Supervisor)
   b. Enter your "FTS Trading Name" (which is 001240)
   c. Check to make sure the "Market IP Address" is correct and your "FTS Trading Name" is 001240
   d. Click "Connect" to connect you to the market.

It is VERY important that you connect to the market. If you have any problem, ask the Experiment Supervisor in your room to help you. After you connect successfully, go to Step 4

4. Read sections 3.0 through 5.0 and Appendix 1 of Experiment Explanation Sheet. You have approximately 5 minutes for this. NOTE: Even though you have read this at least twice before, please still read the sections as it will be useful to refresh your memory. Please note that although the dividend explanation may appear to be different, it has just been reorganized so it is easier to understand – the actual table information is still the same as the previous experiment.

Playing the Trading Game:-

5. Once everyone is prepared, the Market will be readied and a trading page will then appear on the screen. Shortly after this, your Experiment Supervisor will tell you when you may begin trading. While you wait, please do not disturb other people.

DO NOT disconnect from the market at any stage during the experiment. If your PC crashes, please tell the Experiment Supervisor so that they are aware of the situation.

6. At the end of each trial, please write your Actual Last Grade amount in the relevant box on the other side of this piece of paper. Also record the random number generated and whether you will be paid for the Trial (if your Last Grade was higher than the random number, you will be paid for that Trial). Read the other side of this paper for more information.

7. About halfway into the experiment, you will be asked to complete ***Experiment Evaluation Form*** #2 on the PINK piece of paper. Once everyone has completed the questionnaire, the trading will continue when the Supervisors tells you.

Finishing the Experiment:-

8. The Experiment Supervisor will tell you when the trading is finished. Please make sure you record your final Last Grade for the last Trial and then calculate the final payment figure. You will then be asked to complete ***Experiment Evaluation Form #3*** on the YELLOW piece of paper.

9. Once the Experiment Supervisor has told you the experiment has finished, please return all materials (instruction sheet, explanation sheet and the three evaluation forms) to the Experiment Supervisor.

Experiment 1 Payment Record Sheet

Performance Record Sheet 001240

Your Actual Last Grade for this sheet is the "Cumulative Grade" score directly above "Avg:xxx Hi:xxx Lo: x.x".

After the 2nd Trial, you will see two "Cumulative Grade" scores – the first one (below "Time Left") is the total score overall for the game and the second one (above "Avg:xxx Hi:xxx Lo: x.x") is the Actual Last Grade for the last Trial.

Please record your Actual Last Grade (the one above "Avg:xxx Hi:xxx Lo: x.x") and the random number calculated (written on the whiteboard by supervisor) for each Trial in the table below. Ask the supervisor if you are unsure what to do.

	Attendance payment	*Trial 1*	*Trial 2*	*Trial 3*	*Trial 4*	*Trial 5*	*Trial 6*	*Total*
Actual Last Grade (A)	XX							
Randomly drawn hurdle grade (B)	XX							
Payoff ($5.00 if A > B, zero otherwise)	$20.00							

Total payment at the end of the experiment consists of $20 for attendance and $5 for each Trial where the Last Grade (A) exceeds the randomly drawn hurdle grade (B). There will be a maximum of 6 trials in the experiment.

Example:

If at the end of Trial 1, your Actual Last Grade grade was 0.850 (A) and the random number calculated was 0.638 (B)….. you would receive a payment of $5 because A was larger than B. This would mean that so far you would of earned $20 for your attendance and $5 for Trial 1 (total of $25 so far).

Experiment Explanation Sheet

23rd October, 2003

Section 1.0 Introduction

The experiment consists of completion of Experiment Evaluation questionnaires and at least four trials of trading sessions. The questionnaires are described in Section 2.0 of this document and the trading trials from Section 3.0 onwards. Each trial consists of two trading periods of 5 minutes each. You will be are able to **buy** and **sell** securities either by setting a **bid** or an **ask** price or by accepting existing bid or ask prices. The securities may pay dividends at the end of period 1 and period 2, though you will not know the value of these dividends until after the end of trading for that period.

Please remember

1. **Talking and communicating with any of the other students is not allowed, since doing so defeats the purpose of individual tests and having private information in the trading. If you have a question please alert the Experiment Supervisor and he or she will answer your question if possible.**

2. **The terms "Bid" and "Ask" will probably be different from what you learnt in your FINM1001 course. This is because it is from a different point of view. In this computer market, your "Bid" is an offer to buy at a certain price and your "Ask" is the price you are willing to sell at.**

3. **You must hand the instructions up at the end of the experiment. You cannot use pen & paper in this experiment EXCEPT for the consent form, performance record sheet and the three Experiment Evaluation forms.**

Section 2.0 Experiment Evaluation Forms

The Experiment Evaluation Forms are used to measure how confident you feel about the actions you take. It is important that you truthfully answer the questions about how confident you feel at that time. You will be asked to complete the first evaluation form (#1) before you start trading, the second evaluation form (#2) about halfway into the experiment and the 3rd evaluation form (#3) at the end of the experiment.

Section 3.0 The Market

At the beginning of the period you will be allocated **cash** and **securities**. These will vary between individuals. Once trading begins you can buy and sell securities. It is even possible to sell more securities than you own (**short selling**) and this is indicated by a negative number of securities. It is also possible to spend more cash than you have through **borrowing**. Borrowing is indicated by a negative cash balance. At the end of each trial the value of the securities and cash is summed to determine your final wealth, **cumulative grade**.

The securities pay dividends at the end of period 1 and at the end of period 2. Appendix 1 provides a useful summary of the possible dividend combinations offered by the securities.

Both the period 1 and period 2 dividends are randomly selected at the start of the trial for each of the securities. Each participant is also supplied with partial information about the dividend payments for each security within each period. For example: "not x" means that event x will not occur in the period. It is critical to the training that you do not discuss the information given to you with any other participant in the tutorial.

Section 4.0 Trading Screen

Top left hand side of the screen

Trial period: There are a set number of trials that make up an experiment and each trial consists of two trading periods, 1 or 2.

Time left: How many seconds are left in the current trading period.

Cumulative grade: Each trial is independent, but you will earn a trading amount (value of shares and cash held) that cumulates across trials. This is the total grade score earned so far

Last grade (Cumulative Grade): This is the trading score you earned at the end of the last trial. This only appears at the end of each trial (2nd trading period) and consists of the value of the shares plus the remaining cash.

NOTE: This Last Grade value will be used in calculation of your payments for participation in the experiment. The current software version has this labelled as Cumulative Grade – do not confuse it with the other one)

Risk free rate: This is the discount rate and is set to zero for this experiment.

Cash: This is your current cash balance (positive if cash is on-hand and negative if borrowing cash).

Top centre of the screen

Price: Enter the price that you want to pay (receive).

Quantity: The number of shares that you would like to buy (sell).

Sell to Bid or Sell: Sell the shares at the current bid price (no need to enter price if you select this.)

Buy at ask or Buy: Buy the shares at the current ask price (no need to enter price if you enter this.)

Bid button: Entered price and quantity is for a bid transaction

Ask button: Entered price and quantity is for a ask transaction

Clear Bids: Resets the bids made by you to zero if possible

Clear Asks: Resets the asks made by you to zero if possible

Top right hand side of the screen

This section of the screen contains identification information such as the IP number allocated to the machine and the trader names.

Centre of the screen

Private information box: Information available for valuation is displayed in the clear white text box. For example you might get:

Per 1: not x Per 2: not x

This information is relevant to the security name that you have currently selected (by clicking on a security name). This example tells you that the share will not pay x in either period 1 or 2. Please read the instructions to see what can be paid (available during the tutorial).

Note: In this game the share value is the expected value of the dividends you will receive. In trading one this is the sum of dividend you expect at the end of trading period 1 plus the dividend at the end of trading period 2. In trading period 2 this is just the dividend that you expect to occur at the end of this trading period.

Lower left side of the screen

Security details: This section contains the open security market information. Each security's name is listed.

Lower centre of the screen

Best bid and best ask: The yellow boxes normally contain the current best bid (highest price that you can sell at) and best ask (lowest price that you can buy at) for each security.

Hand Signals:

Pointing upwards - increasing a bid price,
Pointing downwards - lowering an ask price,
Pointing to the right - selling at the current bid price.
Pointing to the left - buying at the current ask price.

(Please ignore the other hand signals and the $ symbol as these are not used in this experiment.)

Lower right hand side of the screen

Position: Position contains your current endowment of each security. These are allocated at the beginning of the game along with the cash allocation.

Last: this will contain the last traded price once trading starts.

Payoff: Payoff: this contains realized dividends at the end of each trading period, plus at the end of the trading trial it contains the final value per security.

Section 5.0 Trades

There are four trade buttons that you can click on:

To make an offer to the market:

Bid - This trade consists of an offer to buy a chosen number of units of a security at a chosen price, *remember this may mean the opposite of what you were taught in FINM1001.*

Ask - This trade consists of an offer to sell a chosen number of units of a security at a chosen price, *remember this may mean the opposite of what you were taught in FINM1001.*

To accept an offer in the market:

Sell at bid or sell - This trade amounts to sale of a chosen number of units of the selected security at the bid price currently available in the market and,

Buy at ask or buy - This trade amounts to the purchase of a chosen number of units of the selected security at the ask price currently available in the market.

Do not worry about the different colours (Red, Green and Blue) used in some of the squares, just focus on making what you think are good trades.

Appendix 1 – Dividend determination

NOTE: *the dividends are still the same as the previous experiment but the tables below have been changed to make the information easier to understand.*

Equally likely events affecting each firm, and the dividends paid at the end of each period are:

Firm ABC		Dividend Period 1	Dividend Period 2
Event x	Poor economic conditions, labour strike	0	0
Event y	Poor economic conditions, no strike	12	12
Event z	Fair economic conditions, good labour relations	24	24

Firm CRA		Dividend Period 1	Dividend Period 2
Event w	Poor economic conditions, labour strike	0	8
Event x	Poor economic conditions, no strike	12	8
Event y	Fair economic conditions, no strike	12	12
Event z	Fair economic conditions, good labour relations	24	18

Equally likely events affecting each firm, and the dividends paid at the end of period 2 depend on both the period 1 event and the period 2 event.

Firm ABC

		Period 2 Event		
		x	y	z
Period 1 event	x	0,0	0,0	0,12
	y	12,0	12,12	12,24
	z	24,12	24,12	24,24

Firm CRA

		Period 2 Event			
		w	x	y	z
Period 1 event	w	0,8	0,8	0,12	0,18
	x	12,8	12,8	12,12	12,18
	y	12,8	12,8	12,12	12,18
	z	24,8	24,8	24,12	24,18

Examples for Interpreting the Dividend Tables

Suppose the realized events for ABC are: z in period 1 and x in period 2. At the end of period 1 ABC pays a dividend equal to 24 and at the end of period 2 it pays 12 (see cell row z, column x in the ABC table above (24,12 for period 1 and period 2 respectively)

Suppose the realized events for CRA are: w in period 1 and z in period 2. At the end of period 1 CRA pays a dividend equal to 0 and at the end of period 2 it pays 18 (see cell row w, column z above (0, 18 for period 1 and period 2 respectively)

FINANCIAL TRADING SYSTEMS PROJECT

EXPERIMENT EVALUATION FORM #1

Experiment date: **23 October, 2003** **Trading ID Number: 001240**

1. Age ____ **years**

[For Questions 2, 3 and 4 - please circle correct responses]

2. Gender **Male** **Female**

3. Is English your first language? **Yes** **No**

4. Have you traded in a share market before? (not including FTS) **Yes** **No**

5. Confidence in trading with the FTS trading system game

Listed below are activities that could be completed during financial trading with the FTS system. Please indicate how confident you think you would be in performing each activity by circling one number.

If you are not sure of what you will do or what the question refers to, please circle the "0".

a) Pricing a share

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

b) Setting a bid

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

c) Setting an ask

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

d) Buying

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

e) Selling

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

f) To recognise and respond quickly to buy and sell opportunities

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

g) To make a profit on every deal.

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

h) To make a profit on some deals

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

i) To accumulate significant earnings over time.

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

j) To avoid making losses over time

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

TASK REACTIONS SCALE

Read each item and then mark the answer that most closely describes your FEELINGS, using the scale below. Work fast. Your first reaction is best.

USE THE FOLLOWING SCALE TO INDICATE HOW MUCH YOU FELT THIS WAY:

1= not at all
2=a little
3=moderately
4= quite a bit
5=extremely

1.	UNEASY _____	11.	BOTHERED _____
2.	NERVOUS _____	12.	PLEASANT _____
3.	RELAXED _____	13.	ENERGETIC _____
4.	DISTRESSED _____	14.	ALERT _____
5.	UPTIGHT _____	15.	CHEERFUL _____
6.	PEACEFUL _____	16.	FEARFUL _____
7.	TENSE _____	17.	CONTENTED _____
8.	WORRIED _____	18.	COMFORTABLE_____
9.	JITTERY _____	19.	ACTIVE _____
10.	LIVELY _____	20.	CALM _____

FINANCIAL TRADING SYSTEMS PROJECT

EXPERIMENT EVALUATION FORM #2

Experiment date: **23 October, 2003** **Trading ID Number: 001314**

1. Confidence in trading with the FTS trading system game

Listed below are activities that could be completed during financial trading with the FTS system. Please indicate how confident you feel so far in performing each activity by circling one number.

If you are not sure of what you are doing or what the question refers to, please circle the "0".

a) Pricing a share

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

b) Setting a bid

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

c) Setting an ask

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

d) Buying

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

e) Selling

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

f) To recognise and respond quickly to buy and sell opportunities

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

g) To make a profit on every deal.

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

h) To make a profit on some deals

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

i) To accumulate significant earnings over time.

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

j) To avoid making losses over time

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

2. FTS Stock Valuation

Please answer the following questions about stocks ABC and CRA.

1. For stock ABC, if it is state "x" in the first period and state "z" in the second period:
   a) What is the dividend paid in period 1? _____
   b) What is the dividend paid in period 2? _____
   c) What is the value of the share in the first period? _____
   d) What is the value of the share in the second period? _____

2. What is the minimum value that ABC can take in period 1? _____
3. What is the minimum value that ABC can take in period 2? _____
4. What is the maximum value that ABC can take in period 1? _____
5. What is the maximum value that ABC can take in period 2? _____
6. What is the minimum value that CRA can take in period 1? _____
7. What is the minimum value that CRA can take in period 2? _____
8. What is the maximum value that CRA can take in period 1? _____
9. What is the maximum value that CRA can take in period 2? _____
10. If you know "not z in period 1" for stock ABC what are the possible dividends that could be paid in period 1?

    _____
11. If you know "not y in period 1" and "not x in period 2" for stock CRA what are the possible dividends that could be paid in period 2?

    _____
12. If the current bid and ask prices / depths are $20 / 200 and $24 / 300, respectively and you place a "buy" order for 200 shares what price will you pay for the shares?

    _____
13. If the current bid and ask prices / depths are $20 / 200 and $24 / 300, respectively and you place an ask at a price / depth of $25 / 250 will your new ask be used if the next action in the market is a buy order for 100 shares?

    _____
14. If the current bid and ask prices / depths are $20 / 200 and $24 / 300, respectively and you place an ask at a price / depth of $24 / 250 will your new ask be used if the next action in the market is a buy order for 100 shares?

    _____
15. If the current bid and ask prices / depths are $20 / 200 and $24 / 300, respectively and you place an ask at a price / depth of $23 / 250 will your new ask be used if the next action in the market is a buy order for 100 shares?

    _____

FINANCIAL TRADING SYSTEMS PROJECT

EXPERIMENT EVALUATION FORM #3

Experiment date: **23 October, 2003** **Trading ID Number: 001241**

1. Confidence in trading with the FTS trading system game

Listed below are activities that could be completed during financial trading with the FTS system. Please indicate how confident you were in performing each activity by circling one number.

If you are not sure of what you did or what the question refers to, please circle the "0".

a) Pricing a share

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

b) Setting a bid

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

c) Setting an ask

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

d) Buying

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

e) Selling

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

f) To recognise and respond quickly to buy and sell opportunities

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

g) To make a profit on every deal.

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

h) To make a profit on some deals

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

i) To accumulate significant earnings over time.

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

j) To avoid making losses over time

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

TASK REACTIONS SCALE

Read each item and then mark the answer that most closely describes your FEELINGS DURING THE TRADING PERIOD JUST COMPLETED, using the scale below. Work fast. Your first reaction is best.

USE THE FOLLOWING SCALE TO INDICATE HOW MUCH YOU FELT THIS WAY:

1= not at all
2=a little
3=moderately
4= quite a bit
5=extremely

1.	UNEASY _____	11.	BOTHERED _____
2.	NERVOUS _____	12.	PLEASANT _____
3.	RELAXED _____	13.	ENERGETIC _____
4.	DISTRESSED _____	14.	ALERT _____
5.	UPTIGHT _____	15.	CHEERFUL _____
6.	PEACEFUL _____	16.	FEARFUL _____
7.	TENSE _____	17.	CONTENTED _____
8.	WORRIED _____	18.	COMFORTABLE_____
9.	JITTERY _____	19.	ACTIVE _____
10.	LIVELY _____	20.	CALM _____

Appendix C

Experiment 2 – Consent Form [All participants]

EXPERIMENT CONSENT FORM – 2nd September 2004

The research is designed to test the impact of the introduction of electronic trading systems. In doing so it will touch on the impact of trading systems and information dispersion on individuals and their investment and trading decisions. We have chosen to use an experimental approach as this allows a more controlled environment for the study of individual reaction to financial systems and financial information. The experiments will consist of a market where each participant is given the market ground rules and the participants then trade on a computer system. Each participant is given limited information and the participants can learn from the other participants' trading behaviour to improve their own trading positions. There will be various arrangements of this basic theme with variation in the trading area that students use and in the tools and support systems that the students are able to use.

During the experiment you will complete multiple questionnaires and you will take part in a market share trading game where participants are given some information and then they trade in a market environment with the objective of maximising profits from the trades. The experiment will last about 2 hours and all key-strokes will be recorded for later analysis. There will be no way of linking experimental information back to an individual as each participant is allocated an arbitrary 6-character trader code and no further identifying information is maintained in our records.

Before taking part in this experiment you are requested to sign this form, indicating that you give consent to be part of the experiment and that you give consent for the collection and analysis of both the trading data generated from your trades and the multiple confidence questionnaires.

Please read and sign the following before the experiment commences.

I understand that:
I can withdraw from the experiment at any time;
I will not be placed at risk as a consequence of my participation in this research;
that the experiment is web-based and I am aware that this is not a secure medium;
Talking and communicating with any of the other participants is not allowed during the experiment, since doing so could potentially invalidate the results of the experiment.

Further, I have been given an information sheet and instructions with details of the project and I have also been given the opportunity to ask questions and received satisfactory answers about the research project.

THIS IS TO CERTIFY THAT I HEREBY AGREE TO PARTICIPATE AS A VOLUNTEER IN THE ABOVE NAMED RESEARCH.

If any of the following details are incorrect, please cross it out and write the correct details above

Name (printed) : _____ Signature : _____

Student number : _____ ID# : **002582**

Confidentiality
All information will be treated in a confidential manner. Results will always be reported in such a way that the anonymity of participants is preserved. Your participation is completely voluntary and you may leave this experiment at any time.

Important contact details
If there are any questions at all about the experiment please contact Alex Richardson (Alex.Richardson@anu.edu.au) or Richard Heaney, the chief investigator, (Richard.Heaney@rmit.edu.au).
In particular, if there are any ethical concerns concerning the experiment please contact Sylvia Deutsch (Sylvia.Deutsch@anu.edu.au) of the ANU Human Research Ethic Committee

Experiment 2 – Instruction Sheet [Participants with aid]

Participant Instruction Sheet

2nd September, 2004

Welcome to what is most likely your first experience of being in a university research experiment. If at any time you do not know what to do or have a question, please raise your hand and the supervisor will come help you.

As with most experiments, there are certain rules and conditions that must be followed.

#1 Please listen to your experiment supervisor as they will tell you what to do and when.

#2 Please do not talk to other people participating in the experiment.

#3 The questionnaires are important and you need to answer each question properly when asked. There will be more than one questionnaire, so you need to do the correct one when the supervisor tells you.

Experiment Procedure

Step 1 - Read the experiment consent form and sign if you agree. If you do not agree, you are free to leave the experiment but you will only receive a partial payment.

Step 2 - Wait for the supervisor to tell you when to start the e-bilities. Once told to, load **http://ebilities.com** in Internet Explorer (you will need to use your student account for ANU WWW Cache). Once the site loads, click "**Test-Taker Login**" from the menu on the right. Use the User ID and password below to access test.

User ID: **002582**
Password: **hwgefqqh**

Once the e-bilities online test has started, you have approximately 30 minutes to complete it. If you finish early, please complete Questionnaire #1 while you wait.

Step 3 - Further instructions will be given to you by the supervisor – please listen carefully.

When you start trading, please remember the private information is now in the Excel spreadsheet and not in the FTS program.

Private information box: The private information has been moved to the Excel spreadsheet where the green boxes show the period description and the blue boxes show the event information for that period. For example you might get the following:

ABC private information is:	
Period 1: Not	y
Period 2: Not	z

This tells you that the share will **not pay y** in period 1 and **not pay z** in period 2.

The share value is the value of the dividends you will receive. In Period 1 this is the sum of dividend you expect at the end of trading period 1 + the dividend at the end of trading period 2. In trading period 2 this is just the dividend that you expect to occur at the end of this trading period.

You also receive information about the minimum, maximum and expected values for ABC and CRA. Beside that information for each share is a hint about what the possible values could be. The computer calculates all these values automatically from the private information you receive. The table below is what you would see for the value information where the private information for ABC was "Period 1: Not y Period 2: Not z"

Min Value	Max Value	Exp Value	Hint
0	36	18	ABC value is 0 or 36

Experiment 2 – Instruction Sheet [Participants without aid]

Participant Instruction Sheet

2nd September, 2004

Welcome to what is most likely your first experience of being in a university research experiment. If at any time you do not know what to do or have a question, please raise your hand and the supervisor will come help you.

As with most experiments, there are certain rules and conditions that must be followed.

#1 Please listen to your experiment supervisor as they will tell you what to do and when.

#2 Please do not talk to other people participating in the experiment.

#3 The questionnaires are important and you need to answer each question properly when asked. There will be more than one questionnaire, so you need to do the correct one when the supervisor tells you.

Experiment Procedure

Step 1 - Read the experiment consent form and sign if you agree. If you do not agree, you are free to leave the experiment but you will only receive a partial payment.

Step 2 - Wait for the supervisor to tell you when to start the e-bilities. Once told to, load **http://ebilities.com** in Internet Explorer (you will need to use your student account for ANU WWW Cache). Once the site loads, click "**Test-Taker Login**" from the menu on the right. Use the User ID and password below to access test

User ID: **002583**

Password: **efcvbtxv**

Once the e-bilities online test has started, you have approximately 30 minutes to complete it. If you finish early, please complete Questionnaire #1 while you wait.

Step 3 - Further instructions will be given to you by the supervisor – please listen carefully.

When you start trading, please remember the private information is now in the Excel spreadsheet and not in the FTS program.

Private information box: The private information has been moved to the Excel spreadsheet where the green boxes show the period description and the blue boxes show the event information for that period. For example you might get the following:

ABC private information is:	
Period 1: Not	**y**
Period 2: Not	**z**

This tells you that the share will **not pay y** in period 1 and **not pay z** in period 2.

The share value is the value of the dividends you will receive. In Period 1 this is the sum of dividend you expect at the end of trading period 1 + the dividend at the end of trading period 2. In trading period 2 this is just the dividend that you expect to occur at the end of this trading period.

Experiment 2 – Payment Record Sheet [All participants]

Payment Record Sheet

2nd September 2004

002582

Your Actual Last Grade for this sheet is the "Cumulative Grade" score directly above "Avg:xxx Hi:xxx Lo: x.x".

After the 2nd Trial, you will see two "Cumulative Grade" scores – the first one (below "Time Left") is the total score overall for the game and the second one (above "Avg:xxx Hi:xxx Lo: x.x") is the Actual Last Grade for the last Trial.

Please record your Actual Last Grade (the one above "Avg:xxx Hi:xxx Lo: x.x") and the random number calculated (written on the whiteboard by supervisor) for each Trial in the table below. Ask the supervisor if you are unsure what to do.

	Attendance payment	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Total
Actual Last Grade (A)	XX							
Randomly drawn hurdle grade (B)	XX							
Payoff ($5.00 if A > B, zero otherwise)	$30.00							

Total payment at the end of the experiment consists of $30 for e-bilities and $5 for each Trial where the Last Grade (A) exceeds the randomly drawn hurdle grade (B). There will be a maximum of 6 trials in the experiment.

Example:

If at the end of Trial 1, your Actual Last Grade grade was 0.850 (A) and the random number calculated was 0.638 (B)….. you would receive a payment of $5 because A was larger than B. This would mean that so far you would of earned $30 for e-bilities and $5 for Trial 1 (total of $35 so far).

Experiment 2 – FTS Explanation Sheet [All participants]

FTS Instruction Sheet

2nd September, 2004

ID# - 002582

Section 1.0 Introduction

Before reading any of this, please read the consent form. If you agree to continue with the experiment then please write your name, student number and signature in the spaces provided at the bottom of the consent sheet. You will receive instructions during the experiment from the supervisor – if at any stage you are unsure what to do, please raise your hand and the supervisor will assist you.

Please remember:

1. Talking and communicating with any of the other students is not allowed, since doing so defeats the purpose of individual tests and having private information in the trading. If you have a question please alert the supervisor and he/she will answer your question if possible.

2. You must hand all the documentation back at the end of the experiment when collecting your payment voucher.

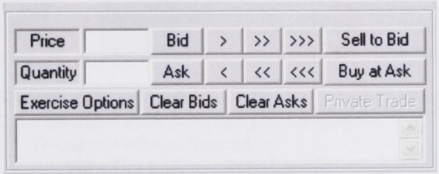
Section 2.0 The Market

At the beginning of the period you will be allocated **cash** and **securities**. These will vary between individuals. Once trading begins you can buy and sell securities. It is even possible to sell more securities than you own (**short selling**) and this is indicated by a negative number of securities. It is also possible to spend more cash than you have through **borrowing**. Borrowing is indicated by a negative cash balance. At the end of each trial the value of the securities and cash is summed to determine your final wealth, **cumulative grade**.

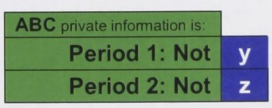
The securities pay dividends at the end of period 1 and at the end of period 2. The "Dividend Determination Sheet" provides a useful summary of the possible dividend combinations offered by the securities. Both the period 1 and period 2 dividends are randomly selected at the start of the trial for each of the securities. Each participant is also supplied with partial information about the dividend payments for each security within each period. For example: "not x" means that event x will **not** occur in the period.

Section 3.0 Trading Screen

Top centre of the screen ← Updated with IMPORTANT information



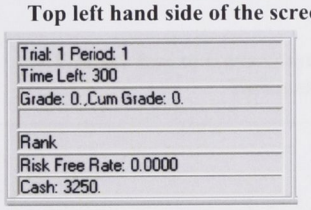
Price: Enter the price that you want to pay (receive).
Quantity: The number of shares that you would like to buy (sell).
Sell to Bid: Sell shares at current bid price (no need to enter price).
Buy at Ask: Buy shares at current ask price (no need to enter price).
Bid button: Entered price and quantity is for a bid transaction
Ask button: Entered price and quantity is for a ask transaction
Clear Bids: Resets the bids made by you to zero if possible
Clear Asks: Resets the asks made by you to zero if possible
Private information box: The private information has been moved to the Excel spreadsheet where the green boxes show the period description and the blue boxes show the event information for that period. For example you might get the following:



This tells you that the share will **not pay y** in period 1 and **not pay z** in period 2.

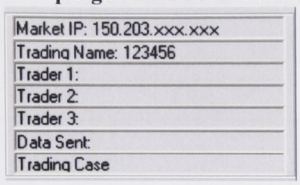
The share value is the value of the dividends you will receive. In Period 1 this is the sum of dividend you expect at the end of trading period 1 + the dividend at the end of trading period 2. In trading period 2 this is just the dividend that you expect to occur at the end of this trading period.

Top left hand side of the screen



Trial & period: There are two periods to each trial.
Time left: How many seconds are left in the current trading period.
Cumulative grade: Each trial is independent, but you will earn a trading amount (value of shares and cash held) that cumulates across trials. This is the total grade score earned so far
Last grade (Cumulative Grade): This is the trading score you earned at the end of the last trial. This only appears at the end of each trial (2nd trading period) and consists of the value of the shares plus the remaining cash.
Risk free rate: This is the discount rate and is set to zero for this experiment.
Cash: Your current cash balance (positive if cash is on-hand and negative if borrowing cash).

Top right hand side of the screen

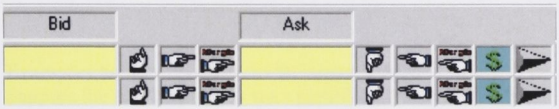


This section of the screen contains identification information such as the market IP number the trader name – not important ☺

Lower left side of the screen

Security details: This section contains the open security market information. Each security's name is listed. Click on the share (ABC or CRA) to select which share you want to trade.

Lower centre of the screen



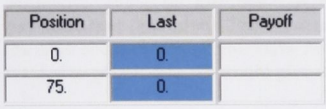
Bid and Ask: The yellow boxes normally contain the current best bid (highest price that you can sell at) and best ask (lowest price that you can buy at) for each security.

Hand Signals:

Pointing upwards - increasing a bid price,
Pointing downwards - lowering an ask price,
Pointing to the right - selling at the current bid price.
Pointing to the left - buying at the current ask price.

(Please ignore the other hand signals and the $ symbol as these are not used)

Lower right hand side of the screen



Position: Position contains your current endowment of each security. These are allocated at the beginning of the game along with the cash allocation.
Last: this will contain the last traded price once trading starts.
Payoff: Payoff: this contains realized dividends at the end of each trading period, plus at the end of the trading trial it contains the final value per security.

Section 4.0 Trades

There are four trade buttons that you can click on:

To make an offer to the market:

Bid - This trade consists of an offer to buy a chosen number of units of a security at a chosen price.
Ask - This trade consists of an offer to sell a chosen number of units of a security at a chosen price.

To accept an offer in the market:

Sell at bid or sell - This trade amounts to sale of a chosen number of units of the selected security at the bid price currently available in the market and,
Buy at ask or buy - This trade amounts to the purchase of a chosen number of units of the selected security at the ask price currently available in the market.

Do not worry about the different colours (Red, Green and Blue) used in some of the squares, just focus on making what you think are good trades.

You are free to trade what shares you want, whenever you want, for whatever price you want.
This means you are free to choose your trading behaviour.

Experiment 2 – Dividend Payment Explanation Sheet [All participants]

Dividend Determination Sheet

2nd September, 2004

ID# - **002582**

ABC		Period 2 Event		
		X	Y	Z
Period 1 event	X	0,0	0,0	0,12
	Y	12,0	12,12	12,24
	Z	24,12	24,12	24,24

CRA		Period 2 Event			
		W	X	Y	Z
Period 1 event	W	0,8	0,8	0,12	0,18
	X	12,8	12,8	12,12	12,18
	Y	12,8	12,8	12,12	12,18
	Z	24,8	24,8	24,12	24,18

Examples for Interpreting the Dividend Tables

Suppose the information you were provided for ABC was "Period 1: Not Y Period 2: Not Z".... this means some possibilities can be removed (see table below).

ABC		Period 2 Event		
		X	Y	~~Z~~
Period 1 event	X	0,0	0,0	~~0,12~~
	~~Y~~	~~12,0~~	~~12,12~~	~~12,24~~
	Z	24,12	24,12	~~24,24~~

This leaves only four possible outcomes; **XX (0,0), XY (0,0), ZX (24,12)** and **ZY (24,12)**. The calculations for ABC value in Period 1 are...

Minimum Value = 0 + 0 = 0
Maximum Value = 24 + 12 = 36
Expected Value = (0+0 + 0+0 + 24+12 + 24+12) / 4 = 18

Minimum value is the least that ABC can be worth, while Maximum Value is the most that ABC can be worth (silly to pay more than this value). The expected value is the weighted average, which in this case means that when you make a decision about the value, you know there is a 50% chance it is worth 0 and a 50% chance that it is worth 36..... so if you wanted to play it safe, 18 would give an even chance of winning or losing.

ABC		Period 2 Event		
		X	Y	~~Z~~
Period 1 event	X	~~0,0~~	~~0,0~~	~~0,12~~
	~~Y~~	~~12,0~~	~~12,12~~	~~12,24~~
	Z	24,12	24,12	~~24,24~~

At the start of Period 2, you receive further information "Period 1: Z Period 2: Not Z". This means you can remove two more possibilities and be left with ZX (24,**12**) and ZY (24,**12**). Because the value you need to consider now is ONLY for the 2nd period, the 2nd value is used to determine possible values for ABC. This means the value is 12 or 12..... which means the only possible value for ABC is 12 – so buy for less than 12 or sell for more than 12.

As you can see, CRA has many more possible combinations but the method for calculating share value is still the same process.

The other side of this sheet of paper has some dividend tables for both ABC and CRA.
You do not have to use these tables, they are just there to save you time drawing them.

You can write on this page and use these tables if you want – it is your choice.

Trial 1

ABC		Period 2 Event		
		X	Y	Z
Period 1 event	X	0,0	0,0	0,12
	Y	12,0	12,12	12,24
	Z	24,12	24,12	24,24

Min Value =
Max Value =
Exp Value =

CRA		Period 2 Event			
		W	X	Y	Z
Period 1 event	W	0,8	0,8	0,12	0,18
	X	12,8	12,8	12,12	12,18
	Y	12,8	12,8	12,12	12,18
	Z	24,8	24,8	24,12	24,18

Min Value =
Max Value =
Exp Value =

Trial 2

ABC		Period 2 Event		
		X	Y	Z
Period 1 event	X	0,0	0,0	0,12
	Y	12,0	12,12	12,24
	Z	24,12	24,12	24,24

Min Value =
Max Value =
Exp Value =

CRA		Period 2 Event			
		W	X	Y	Z
Period 1 event	W	0,8	0,8	0,12	0,18
	X	12,8	12,8	12,12	12,18
	Y	12,8	12,8	12,12	12,18
	Z	24,8	24,8	24,12	24,18

Min Value =
Max Value =
Exp Value =

Trial 3

ABC		Period 2 Event		
		X	Y	Z
Period 1 event	X	0,0	0,0	0,12
	Y	12,0	12,12	12,24
	Z	24,12	24,12	24,24

Min Value =
Max Value =
Exp Value =

CRA		Period 2 Event			
		W	X	Y	Z
Period 1 event	W	0,8	0,8	0,12	0,18
	X	12,8	12,8	12,12	12,18
	Y	12,8	12,8	12,12	12,18
	Z	24,8	24,8	24,12	24,18

Min Value =
Max Value =
Exp Value =

Trial 4

ABC		Period 2 Event		
		X	Y	Z
Period 1 event	X	0,0	0,0	0,12
	Y	12,0	12,12	12,24
	Z	24,12	24,12	24,24

Min Value =
Max Value =
Exp Value =

CRA		Period 2 Event			
		W	X	Y	Z
Period 1 event	W	0,8	0,8	0,12	0,18
	X	12,8	12,8	12,12	12,18
	Y	12,8	12,8	12,12	12,18
	Z	24,8	24,8	24,12	24,18

Min Value =
Max Value =
Exp Value =

Trial 5

ABC		Period 2 Event		
		X	Y	Z
Period 1 event	X	0,0	0,0	0,12
	Y	12,0	12,12	12,24
	Z	24,12	24,12	24,24

Min Value =
Max Value =
Exp Value =

CRA		Period 2 Event			
		W	X	Y	Z
Period 1 event	W	0,8	0,8	0,12	0,18
	X	12,8	12,8	12,12	12,18
	Y	12,8	12,8	12,12	12,18
	Z	24,8	24,8	24,12	24,18

Min Value =
Max Value =
Exp Value =

Trial 6

ABC		Period 2 Event		
		X	Y	Z
Period 1 event	X	0,0	0,0	0,12
	Y	12,0	12,12	12,24
	Z	24,12	24,12	24,24

Min Value =
Max Value =
Exp Value =

CRA		Period 2 Event			
		W	X	Y	Z
Period 1 event	W	0,8	0,8	0,12	0,18
	X	12,8	12,8	12,12	12,18
	Y	12,8	12,8	12,12	12,18
	Z	24,8	24,8	24,12	24,18

Min Value =
Max Value =
Exp Value =

Experiment 2 – Questionnaire 1 [Participants with aid]

FINANCIAL TRADING SYSTEMS PROJECT

QUESTIONNAIRE #1A

Date: 2nd September, 2004 **Trader ID#: 002582**

Introduction

We would like your opinions about share trading before you experience the FTS game again.

1. Secret code

We would like to generate your own unique secret code to be used in later questionnaires, which cannot be used to identify your response by anyone else. To do this, please answer the following questions:

(a) Please give the first and last letter in your mother's maiden name: ____
For example, if you mother's maiden name was "CHEN", enter 'CN"

(b) Give the day of the month for your birthday: ____
For example, if you were born on the 9th of January, enter "09"

(c) Give the first letter of the city in which you were born: __
For example, if you were born in Melbourne, enter "M"

2. Confidence in trading with the FTS trading system game

Listed below are activities that could be completed during financial trading with the FTS system. Please indicate how confident you feel in performing each activity by circling one number.

If you are not sure of what to do or what the question refers to, please circle the "0".

a) Pricing a share

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

b) Setting a bid

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

c) Setting an ask

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

d) Buying

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

e) Selling

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

3. FTS Stock Valuation

Please answer the following questions about stocks ABC. You may need to read the "Dividend Determination Sheet" to answer these questions.

1. For stock ABC, if it is state "y" in the first period and state "x" in the second period:

   a) What is the dividend paid in period 1? _____

   b) What is the dividend paid in period 2? _____

   c) What is the value of the share in the first period? _____

   d) What is the value of the share in the second period? _____

2. What is the minimum value that ABC can take in period 1? _____

3. What is the maximum value that ABC can take in period 2? _____

4. If you know "not y in period 1" for stock ABC what are the possible dividends that could be paid in period 1?

   _____

5. If the current bid and ask prices / depths are \$10 / 200 and \$14 / 300, respectively and you place a "buy" order for 200 shares, what price will you pay for the shares?

   \$_____ per share

6. If the current bid and ask prices / depths are \$10 / 200 and \$14 / 300, respectively and you place an ask at a price / depth of \$15 / 250, will your new ask be used if the next action in the market is a buy order for 100 shares?

   ☐ Yes ☐ No

7. If the current bid and ask prices / depths are \$10 / 200 and \$14 / 300, respectively and you place an ask at a price / depth of \$13 / 250, will your new ask be used if the next action in the market is a buy order for 100 shares?

   ☐ Yes ☐ No

Experiment 2 – Questionnaire 2 [Participants with aid]

FINANCIAL TRADING SYSTEMS PROJECT

QUESTIONNAIRE #2A

Date: 2nd September, 2004 **Trader ID#: 002582**

Listed below are some statements about the decision aid showing your private information and share values in Excel. Please indicate you level of agreement.

If you are not sure of what to do or what the question refers to, please circle the "0".

1. Usefulness of aid

a) Using the decision aid will improve my trading performance

0	1	2	3	4	5	6	7
Not sure	Strongly Disagree	Quite	Slightly	Neither	Slightly	Quite	Strongly Agree

b) Using the decision aid when trading, will increase my productivity.

0	1	2	3	4	5	6	7
Not sure	Strongly Disagree	Quite	Slightly	Neither	Slightly	Quite	Strongly Agree

c) Using the decision aid will enhance the effectiveness of my trading.

0	1	2	3	4	5	6	7
Not sure	Strongly Disagree	Quite	Slightly	Neither	Slightly	Quite	Strongly Agree

d) I will find the decision aid useful for trading.

0	1	2	3	4	5	6	7
Not sure	Strongly Disagree	Quite	Slightly	Neither	Slightly	Quite	Strongly Agree

2. Trust of aid

e) I understand how the aid calculated its hints.

0	1	2	3	4	5	6	7
Not sure	Strongly Disagree	Quite	Slightly	Neither	Slightly	Quite	Strongly Agree

f) I trust the hints the aid provided.

0	1	2	3	4	5	6	7
Not sure	Strongly Disagree	Quite	Slightly	Neither	Slightly	Quite	Strongly Agree

Experiment 2 – Questionnaire 3 [Participants with aid]

FINANCIAL TRADING SYSTEMS PROJECT

QUESTIONNAIRE #3A

Date: 2nd September, 2004 **Trader ID#: 002582**

Listed below are some statements about the decision aid showing your private information and share values in Excel. Please indicate you level of agreement.

If you are not sure of what to do or what the question refers to, please circle the "0".

1. Usefulness of aid

a) Using the decision aid improved my trading performance

0	1	2	3	4	5	6	7
Not sure	Strongly Disagree	Quite	Slightly	Neither	Slightly	Quite	Strongly Agree

b) Using the decision aid when trading, increased my productivity.

0	1	2	3	4	5	6	7
Not sure	Strongly Disagree	Quite	Slightly	Neither	Slightly	Quite	Strongly Agree

c) Using the decision aid enhanced the effectiveness of my trading.

0	1	2	3	4	5	6	7
Not sure	Strongly Disagree	Quite	Slightly	Neither	Slightly	Quite	Strongly Agree

d) I found the decision aid useful for trading.

0	1	2	3	4	5	6	7
Not sure	Strongly Disagree	Quite	Slightly	Neither	Slightly	Quite	Strongly Agree

2. Trust of aid

e) I understand how the aid calculated its hints.

0	1	2	3	4	5	6	7
Not sure	Strongly Disagree	Quite	Slightly	Neither	Slightly	Quite	Strongly Agree

f) I trust the hints the aid provided.

0	1	2	3	4	5	6	7
Not sure	Strongly Disagree	Quite	Slightly	Neither	Slightly	Quite	Strongly Agree

3. FTS Stock Valuation

Please answer the following questions about stocks ABC. You may need to read the "Dividend Determination Sheet" to answer these questions.

1. For stock ABC, if it is state "y" in the first period and state "x" in the second period:

   a) What is the dividend paid in period 1? _____

   b) What is the dividend paid in period 2? _____

   c) What is the value of the share in the first period? _____

   d) What is the value of the share in the second period? _____

2. What is the minimum value that ABC can take in period 1? _____

3. What is the maximum value that ABC can take in period 2? _____

4. If you know "not y in period 1" for stock ABC what are the possible dividends that could be paid in period 1?

   _____

5. If the current bid and ask prices / depths are \$10 / 200 and \$14 / 300, respectively and you place a "buy" order for 200 shares, what price will you pay for the shares?

   \$_____ per share

6. If the current bid and ask prices / depths are \$10 / 200 and \$14 / 300, respectively and you place an ask at a price / depth of \$15 / 250, will your new ask be used if the next action in the market is a buy order for 100 shares?

   ☐ Yes ☐ No

7. If the current bid and ask prices / depths are \$10 / 200 and \$14 / 300, respectively and you place an ask at a price / depth of \$13 / 250, will your new ask be used if the next action in the market is a buy order for 100 shares?

   ☐ Yes ☐ No

Experiment 2 – Questionnaire 1 [Participants without aid]

FINANCIAL TRADING SYSTEMS PROJECT

QUESTIONNAIRE #1

Date: 2nd September, 2004 **Trader ID#: 002582**

Introduction

We would like your opinions about share trading before you experience the FTS game again.

1. Secret code

We would like to generate your own unique secret code to be used in later questionnaires, which cannot be used to identify your response by anyone else. To do this, please answer the following questions:

(a) Please give the first and last letter in your mother's maiden name: ____
For example, if you mother's maiden name was "CHEN", enter 'CN"

(b) Give the day of the month for your birthday: ____
For example, if you were born on the 9th of January, enter "09"

(c) Give the first letter of the city in which you were born: __
For example, if you were born in Melbourne, enter "M"

2. Confidence in trading with the FTS trading system game

Listed below are activities that could be completed during financial trading with the FTS system. Please indicate how confident you feel in performing each activity by circling one number.

If you are not sure of what to do or what the question refers to, please circle the "0".

a) Pricing a share

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

b) Setting a bid

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

c) Setting an ask

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

d) Buying

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

e) Selling

0	1	2	3	4	5
Not sure	Not at all confident		Moderately confident		Totally confident

3. FTS Stock Valuation

Please answer the following questions about stocks ABC. You may need to read the "Dividend Determination Sheet" to answer these questions.

1. For stock ABC, if it is state "y" in the first period and state "x" in the second period:

    a) What is the dividend paid in period 1? _____

    b) What is the dividend paid in period 2? _____

    c) What is the value of the share in the first period? _____

    d) What is the value of the share in the second period? _____

2. What is the minimum value that ABC can take in period 1? _____

3. What is the maximum value that ABC can take in period 2? _____

4. If you know "not y in period 1" for stock ABC what are the possible dividends that could be paid in period 1?

    _____

5. If the current bid and ask prices / depths are $10 / 200 and $14 / 300, respectively and you place a "buy" order for 200 shares, what price will you pay for the shares?

    $_____ per share

6. If the current bid and ask prices / depths are $10 / 200 and $14 / 300, respectively and you place an ask at a price / depth of $15 / 250, will your new ask be used if the next action in the market is a buy order for 100 shares?

    ☐ Yes ☐ No

7. If the current bid and ask prices / depths are $10 / 200 and $14 / 300, respectively and you place an ask at a price / depth of $13 / 250, will your new ask be used if the next action in the market is a buy order for 100 shares?

    ☐ Yes ☐ No

Experiment 2 – Questionnaire 2 [Participants without aid]

FINANCIAL TRADING SYSTEMS PROJECT

QUESTIONNAIRE #2

Date: **2nd September, 2004** **Trader ID#:** **002582**

1. FTS Stock Valuation

Please answer the following questions about stocks ABC. You may need to read the "Dividend Determination Sheet" to answer these questions.

1. For stock ABC, if it is state "y" in the first period and state "x" in the second period:
   a) What is the dividend paid in period 1? _____
   b) What is the dividend paid in period 2? _____
   c) What is the value of the share in the first period? _____
   d) What is the value of the share in the second period? _____
2. What is the minimum value that ABC can take in period 1? _____
3. What is the maximum value that ABC can take in period 2? _____
4. If you know "not y in period 1" for stock ABC what are the possible dividends that could be paid in period 1?
   _____
5. If the current bid and ask prices / depths are \$10 / 200 and \$14 / 300, respectively and you place a "buy" order for 200 shares, what price will you pay for the shares?
   \$_____ per share
6. If the current bid and ask prices / depths are \$10 / 200 and \$14 / 300, respectively and you place an ask at a price / depth of \$15 / 250, will your new ask be used if the next action in the market is a buy order for 100 shares?
   ☐ Yes ☐ No
7. If the current bid and ask prices / depths are \$10 / 200 and \$14 / 300, respectively and you place an ask at a price / depth of \$13 / 250, will your new ask be used if the next action in the market is a buy order for 100 shares?
   ☐ Yes ☐ No